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SOLID MILK AND ITS MANUFACTURE.*

IT is difficult to mention an article of food that is of greater importance, or enters more largely into modern food economy, than milk. Commensurate with the magnitude and consequence of the milk industry have been the efforts of scientists, sanitary, chemical, industrial, to remove from the dairy the danger of propagating disease through the agency of the milk. The perishable nature of the subject has placed many difficulties in the way, not only of obviating the danger as a germ carrier, but also has prevented to a large extent the centralization of the industry and the subsequent cheapening of the product. In consequence, the efforts of scientists and chemists interested in this question have been directed, during late years, toward devising a method whereby milk might be prepared in solid form and still retain those properties which make it of such value while in a liquid condition.

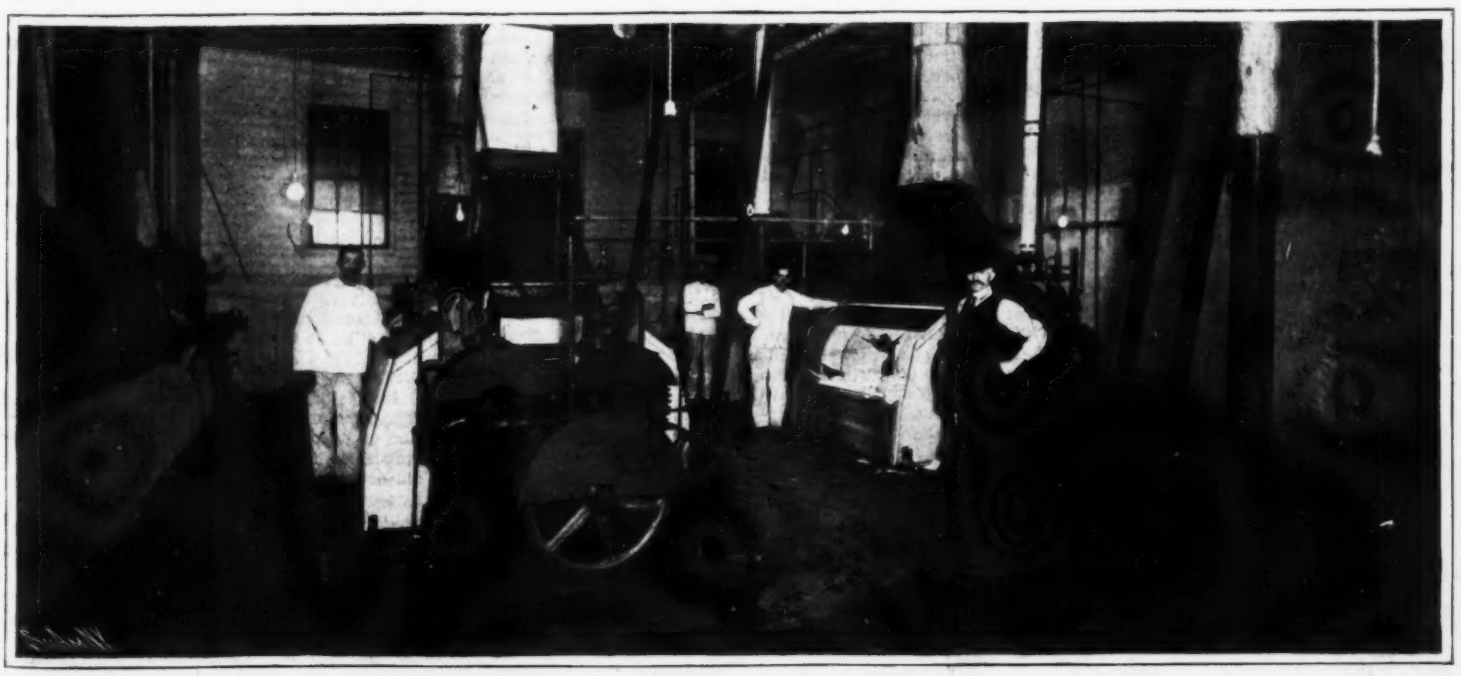
Condensed milk, the first step in this direction, while possessing many advantages still has certain drawbacks which prevent its use for many purposes. The next step was, naturally, the complete conversion of milk into a solid or powdered form. The underlying principle in making both condensed and dry milk is extremely simple, and consists merely in evaporating a portion or all of the water contained therein. The difficulty lies in the manner in which this is done, for the dry milk to be of practical utility must be perfectly soluble and must, in effect, regain its original condition when dissolved in water.

A HEAP OF DRY MILK.

Strictly speaking, milk in dry form is not an entirely new product, for several brands of it have been on the market for a number of years. Most of these, however, possess the disadvantage of incomplete solubility, and are liable to leave numbers of small clots or lumps in the dissolved milk, and this frequently emits an unpleasant odor of cheese upon standing undisturbed for a short period. These forms of dry milk are manufactured by the so-called slow-evaporation or low-temperature process, for many scientists have maintained that rapid evaporation at high temperature would precipitate the albumin, and consequently make the product insoluble to a degree. That the reverse is true, appears to have been proven by Dr. John A. Just, of Syracuse, N. Y., who has been granted patents covering both his process for making dry milk and the product of the same, and this process is almost a complete contradiction of other methods now in use. The manufacturers of dry milk, according to the Just method, as well as many others who have used it, claim really exceptional qualities for the product. These are perfect solubility, permitting the reconstitution of natural milk with all its organoleptic properties, the complete retention

THE JUST MILK-DRYING MACHINE.

A CORNER IN THE LABORATORY AND TESTING ROOM.



WHERE DRY MILK IS MADE.

THE JUST DRY MILK PROCESS.

*Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

of all the nutritive principles and the assimilability of fresh milk, and perfect preservability and absolute sterility.

The apparatus designed by Dr. Just is of extreme simplicity. It consists essentially of two hollow, polished metal cylinders placed side by side and slightly separated from each other. They are mounted in a strong iron framework, and revolve in opposite directions at a rate of approximately six revolutions per minute. Superheated steam at a pressure of about forty pounds per square inch is introduced into these cylinders, and heats them to a temperature considerably above 212 deg. F. The milk is fed continuously into the space between the upper halves of the faces of the two cylinders, and the evaporation begins as soon as the liquid comes into contact with the heated metal surface. The milk passes gradually between the cylinders, and is carried in a thin, uniform layer upon each until it reaches a knife blade held in contact with the surface, which removes the solid, moist milk residue in continuous sheets. These sheets dry upon cooling, and are easily crumbled into a flaky white powder. One of the accompanying engravings shows a machine of the Just type in operation, the exposed cylinder being covered with a film of the drying milk; another shows a machine at rest, with the moist, continuous layer of evaporated milk purposely broken.

The company which employs the Just process possesses two large creameries, one at Adams and the other at Mexico, N. Y. Here the most scrupulous care is taken to insure the absolute sterility of the product, the milk being pasteurized and carefully examined before it is fed into the machine. The buildings of the plants are kept exceedingly clean, the farmers supplying the raw product are under close supervision, and the finished dry milk is carefully tested before packing for shipment. For the manufacture of dry milk, various grades of the raw material are used, from full-cream milk to skim milk, the quality of the resulting manufactured article varying in proportion and according to the purpose for which it is intended.

Analyses made at the Carnegie Laboratory, at the Experiment Station of the State of Massachusetts, at the University of West Virginia, and by the Department of Agriculture of the United States, have shown that no determinable chemical change takes place in the milk that undergoes the drying operation. Numerous bacteriological investigations by the Carnegie Laboratory, by the Department of Health of New York city, and by the Cornell and New York universities, have proven beyond doubt that the dry milk, as it leaves the machine, is sterile, and that living and virulent germs introduced into the raw milk are destroyed by the drying action. Extensive tests to determine the digestibility and food value of the new product were made through the Department of Health of New York city, with the assistance of various charitable institutions. A number of children, for the most part from the poorer tenement-house districts, and from five days to two years old, were fed on dried milk exclusively, during the three hottest months of the summer. The results are said to be without parallel, not one child dying and all gaining weight normally. These experiments appear to have brought out the fact that the dried milk does not clot in the stomach like ordinary milk, but possesses the digestible qualities of human milk.

The average composition of milk powder, produced by drying an equal mixture of full-cream milk and separated milk, is as follows:

	Per cent.
Casein	37.45
Butter fat	15.80
Milk sugar	33.11
Milk salts	7.34
Moisture	6.30

In drying, 85 per cent of its weight is lost and its volume, of course, greatly reduced, and this with its indefinite conservability makes it easy and cheap to ship. Compressed into tablets, dry milk would have many uses, for instance, in armies. The product should be of great value to exploring, camping, and yachting parties, as in addition to the above-mentioned qualities the reconstituted milk is absolutely free from the unpleasant, cooked taste of condensed milk. The reconstitution of the milk from the powder is very simple. All that is necessary is to add the required amount of water, according to the directions furnished by the manufacturer.

NOVELTIES IN THE SPINNING AND TEXTILE INDUSTRIES.

ONE of the most prominent features in the recent progress of the spinning and textile industries, is the endeavor to introduce new raw materials and fibers not hitherto used for such purposes. These new raw materials are very largely similar to or even identical with those used in paper making. The chief of them is the cellulose of conifers, purified by chemical means, and freed from infiltrated substances, the so-called sulphite cellulose. But asbestos also, after suitable preparation, has been mixed with cotton fiber and has been tried for making thread according to the new spinning process.

In preparing yarns from cellulose, attempts were first made to attain the desired end by purely mechanical means, and in the dry way. Recently a new process has been used, in which very short fibers are spun in the wet way. By the old method the woody part of the fibers was loosened mechanically by carding, rolling, etc. In this way a product is obtained which is not as durable as might be desired. The fibers freed from ligneous material by proper treatment with calcium bisulphite lye are of considerably better quality than those prepared by purely mechanical means, and are worked up into thread by the wet method.

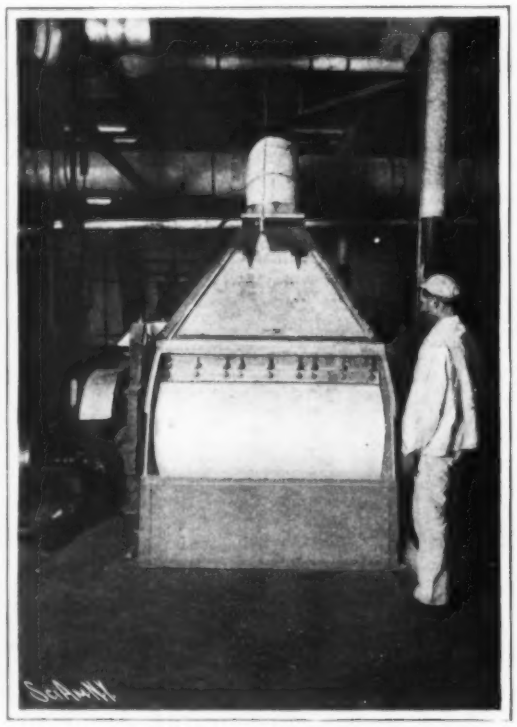
In the earlier forms of the process, finished paper was used, which was cut into strips and, by a series of spinning and burnishing operations, converted into yarn, being sometimes spun together with a cotton thread, to add to the strength of the product. A yarn of this kind, known as xylolin thread, is used for the weft of drill cloth for towels, vests, etc. A complete washable suit of this kind is obtainable at the price of 7 to 10 marks ($2 to $2.50).

The more recent patents on which the modern development of the cellulose yarn industry is based, differ from the process indicated above, in that they abandon the comparatively expensive preliminary production of paper, and resort to the direct manufacture of spun goods. The wood-cellulose is beaten in a finisher, undergoes some further subdivision, and is then transformed by means of sieves into a kind of very thin, pasty board. The conversion of this into thread can be effected in a variety of ways.

The Altdamm Works, near Stettin, Prussia, have placed goods prepared in this way on the market under the name of "Licella thread." The new industry has found some footing also in Spain, Holland, and Russia.

These cellulose materials have one disadvantage, which at present stands in the way of their more universal application: on wetting they lose their strength entirely, regaining it, however, on drying. Goods woven from a mixture of Licella thread with cotton, or similar mixtures, however, possess considerable strength also when wet. Towels made with flax warp and cellulose weft have proved quite serviceable, and can be washed several times.

Peat has also been used as a raw material for the manufacture of yarns and fabrics. The product, when looked at under the microscope, is seen to consist of tubular, hollow fibers. This accounts for its peculiarly marked heat and sound insulating character, and its high absorbent power. Coupled with the latter, its natural antiseptic properties render it valuable for the preparation of medicated cotton. It is also made into carpets, covering for hot pipes, etc.



MACHINE IN OPERATION, SHOWING FILM OF DRY MILK.

THE JUST DRY MILK PROCESS.

Attempts have also been made to produce long fibers for spinning, and short fibers for paper making, from the leaves which inclose the ears of the Indian corn plant. The earlier processes yielded a brittle product, but the fiber prepared according to a recent German patent (130,851) is long and supple, and there is little waste in its production. As a by-product short fibers, which are worked up into paper, are also obtained.

The leaves in question are first boiled with a caustic potash or lime lye, and then washed in water. During this operation the long fibers become separated from the short, which are further worked up separately. The washed fibers are then treated with dilute acetic acid. After washing once more the material is dried. The long fibers are said to be well adapted for spinning.

The German patent 145,814 deals with a process for producing a substitute for horsehair. The raw material is the fiber of the cocoanut tree, and other vegetable fibers. These are first degreased in an alcoholic solution, and are then brought into a bath in which they are by one single operation mordanted, dyed, and stiffened. This bath contains logwood and sumach-extract and ferrous sulphate. Its temperature is kept for some minutes at about 38-40 deg., and is then allowed to sink. The fibers are afterward carded and combed, and placed in another bath, consisting of glue, nigrosine, acetic acid, and oleic acid, mixed with or dissolved in water, this bath serving to increase their pliability. The temperature is again raised to 30-40 deg. for three minutes, and the material is washed and dried. After a final carding and combing the fibers are ready for use.

Another process which deserves mention here, is that of German patent 130,979, which furnishes a valuable method of obtaining long, undamaged ramie fibers. The inventor has found the general impression, that the application of cold in preparing the ramie fiber tends to crumble it up, to be incorrect, but that on the contrary, when the proper precautions are observed, particularly long fibers can be obtained in this way. The following points have to be considered:

1. The plants must be worked up in their fresh state.
2. The cold must be applied quickly and must be severe.
3. The time of the cold treatment must be duly limited.
4. After this treatment the plants must be thawed up as quickly as possible.
5. The removal of the woody portion must be effected immediately.

The last two precautions, (4) and (5), are necessary because it has been observed that the effect of refrigeration, by which it becomes possible to free the fiber, is not lasting, but disappears more or less rapidly after thawing. If, therefore, the plants are left to themselves for some time after freezing and thawing, the union between the fibers and the stem regains its original strength.

A peculiar process for the production of a material composed of a woven fabric on the one hand and cork on the other, is the subject of a German patent (151,813), though originally a French invention. Thin plates of cork, after having resins and gums removed from them by means of suitable solvents, are united by pressure with a suitable cloth. The solution used to extract the resins and gums consists of 90 parts oil of turpentine, 8 parts of alcohol, and 2 parts of ether. After it comes out of the bath the cork is laid out in a drying chamber. The two layers of cork and cloth are then subjected to a strong pressure, by passing them between rolls. The product so obtained is intended more particularly as a substitute for waterproof cloth.

The raw materials which have of recent times been proposed for the manufacture of yarns and fabrics are not, however, exclusively of vegetable origin. The sinews of slaughtered animals have also been used for this purpose, the resulting product being characterized by great toughness, while the raw material, being derived from the waste of slaughter-houses, is correspondingly cheap. The sinews are first freed from adhering skin, fat, flesh, etc., are tanned, and dried, and "teased" to a suitable thickness by appropriate mechanical treatment.

The resulting material may be woven into fabrics either direct, or after further treatment (dyeing, tanning, impregnating), etc. In case the first method is adopted, the fabric itself may afterward be subjected to these processes.

A material which has been attracting considerable attention of late is the so-called artificial silk. That this has come to occupy quite an important position on the world's market can be gathered from the fact that its annual production at the present time is, according to Thiele, about 1,000,000 kilogrammes, while that of natural silk for 1902 was estimated at 33,000,000 kilogrammes. At the beginning of the year 1904 1 kilogramme of artificial silk was sold for 30 marks ($7.50).

The methods which have been in use hitherto for the production of artificial silk can be classified according to the nature of the solution which serves as the starting point. Such solutions are:

1. The various nitrocelluloses, sometimes mixed with resins, oils, fish-glue, etc., in various solvents. From these the "collodion silks" are obtained.
2. The esters of cellulose with organic acids, especially acetic acid, "acetate silks."
3. Viscose (cellulose xanthogenate): viscose silks.
4. Cellulose dissolved in ammoniacal solution of copper oxide.
5. Cellulose dissolved in zinc chloride.
6. Cellulose dissolved in sulphuric or phosphoric acid.
7. The solution of acid-cellulose in caustic soda solution.
8. Solutions which do not contain any cellulose or its derivatives.

Of the many new processes for the preparation of collodion silks we will only mention one, that of French patent 328,054, which aims at diminishing the inflammability of the material by treating the material with aluminium salts, especially the acetate, or pure alumina. The same effect is also said to be attainable by the addition of 10 to 20 parts of barium chloride.

Of processes in connection with the silk prepared by the aid of ammoniacal copper oxide one also deserves mention, according to which salts of the rare earths are added to the cellulose solution, for the purpose of preparing therefrom filaments for incandescent mantles. In order to precipitate the hydroxides of the corresponding metals, simultaneously with the formation of the filaments, the latter are produced in a solution which precipitates these earths, e. g., a solution of potassium cyanide.

Considerable attention is at this time being attracted by the viscose silk, which first appeared on the market at the beginning of the year 1904. The formula of this body is given as $C_6H_9O_5CSS\,Na$. For an account of its

preparation the reader is referred to the Jl. Soc. Dyers and Col., 1903, p. 230 (Stearn).

It is usual to effect the precipitation of the viscose threads by means of ammonium salts; in the course of this process the alkali sulphide of the viscose reacts with these ammonium salts, leading to the formation of ammonium sulphide and sulphydrate. This causes the thread to be sticky, and gives a good deal of trouble in the subsequent spinning operation. To overcome this difficulty it is proposed (German patents 132,743 and 153,817) to pass the thread, as it comes from the ammonium salt bath, through a solution of a metallic salt which precipitates an insoluble sulphide from alkali sulphides. A 10 per cent solution of ferrous sulphate serves very well. After this treatment the fibers are spun, and the adhering sulphide is then removed by means of dilute acid.

Much work has also been done in connection with cellulose acetate. A use for which this material has been found to be eminently adapted, is for insulating electric conductors. Celestron silk is used, especially in America, for wrapping fine wires. According to Witt, cellulose acetate is nearly equal to natural silk in its strength and power of resisting damp.

As regards the means for distinguishing natural from artificial silk, Herzog has pointed out that of all samples examined by him, the artificial silk invariably showed marked dichroism, while the natural material is not dichroic.

In the treatment of wool some new developments have also taken place, which deserve mention. One of these is the introduction of "boleg oil" as a grease for woolen and other fibers. This is prepared in such manner from mineral oil that it is readily emulsified with water, and on this depends its special advantage for the use indicated, as it is readily washed out from the material, when this is to be dyed, simply by means of soap and water. The use of mineral oil in this connection is a new departure.

For the purpose of washing the wool J. Koning proposes to prepare an ammonia soap upon the fiber itself, at the temperature usually employed in degreasing wool, viz., 30-50 deg. C.

The advantages claimed for this method are, that the soap comes into action immediately on its formation, without loss of ammonia, and without harmful effects, and that the fiber is covered much more uniformly with soap than it could be by simply wetting it with a soap solution. The wool, after a preliminary washing, is placed in the first trough of a washing machine, a little soda or potash is added, or a little ammonia. After going through the press the wool passes on to a band conveyor, where it is sprinkled with a fatty acid. It is then put through another press, and finally enters a bath of ammonia solution, kept at the temperature usually employed in wool washing. A very active and homogeneous ammonia soap is said to be thus produced on the fiber. Finally the wool is rinsed in water.

Interesting also are the efforts which have been made to transform sheep's wool and other keratin fibers in such manner that they can be treated with comparatively strong and hot alkalies without injury. This effect can be produced by means of formaldehyde, applied either hot or cold, or in the form of vapor, and without subsequent washing. In the dyeing of sheep's wool and of half woolen goods with sulphur dyes in alkaline solution, in printing on wool, etc., this process should prove valuable by rendering it possible to apply stronger solution, a higher temperature, and more prolonged action.

Finally we will mention a process by which wool is so changed in character, that it readily takes up basic dye-stuffs, while losing almost entirely its affinity for the usual acid woolen dyes. This result is attained by treating the wool (and similar animal fibers) for a short time in the cold with sulphuric acid of 62 deg. Bé., and afterward in successive baths of acid of diminishing concentration. This treatment might, for instance, obviously be used to produce two-color effects in pure woolen fabrics.

OBSERVATIONS ON COLORING AND BLEACHING PLUMES.

FEATHERS, in their natural state are not adapted to undergo the processes of dyeing and bleaching; they must be prepared by having their oil and dirt removed, says Franz Euler, a practical dyer, in Neueste Erfindungen. This is usually done by washing in moderately warm soap and water, and rinsing in warm and cold water; or the oil may be chemically removed by the use of benzine. To remove it entirely, the feathers must be left in the cleansing fluid for a half-hour or more, even for an hour, when they may be considered perfectly free from oil, and may be subjected to the process of bleaching.

Since a method has been discovered of almost entirely destroying the natural coloring matter of feathers, by the use of hydrogen peroxide, without injuring their texture, the bleaching of plumes has become a profitable industry.

In specially constructed glass troughs, made the length of an average ostrich feather, fifteen or twenty of these feathers can be treated at a time. The bleaching fluid is made from a 30 per cent solution of hydrogen peroxide, with enough ammonia added to make it neutral. When neutral, blue litmus paper will not turn red, and red will take a pale violet tinge. The previously cleansed feathers are entirely immersed in this bleaching bath, which may be diluted if desired, the trough is covered with a glass plate and put in a dark place. From time to time the feathers are stirred and turned; adding more hydrogen peroxide. This process requires 10 to 12 hours and if necessary should be repeated. After bleaching, they are rinsed in condensed water or rain water, dried in the air, and kept in motion while drying.

The bleaching fluid, which will still contain many useful constituents, can be reserved for further use, but should be kept well covered.

To insure success in coloring feathers in delicate colors, they must first be free from all impurities, and evenly white. It frequently happens in the case of thick and heavy ostrich plumes that part of the quill remains uncolored. The cause of this is not to be found in imperfect cleansing, but is rather due to the fact that the horny part of the feather can not so easily take in the dye. It has been found of advantage to rub this part of the plume, while still moist, with carbonate of ammonia, before the dyeing is begun.

Among the different methods of dyeing, the following have been found best adapted to feathers.

1. A boiling hot neutral solution, the feathers to be dried in a rotating apparatus. Suitable dyes for this method are chrysoidin, A, C; crystal vesuvin, 4 B C; phosphin extra, leather yellow, O H; leather red, O, G B; leather brown, O; morocco red, O; azophosphine, G O, B R O; fuchsin, cerise, G R; grenadin, O; safranin, O; methylene violet, malachite green, crystal brilliant green, methylene green, methylene gray, coal black II.

2. A boiling hot sulphuric solution. Dyes, acid fuchsin, orseillin, R B; acid cerise, O; acid maroon, O; opal blue, blue de Lyon, R B; cotton blue No. 2, China blue No. 2, naphthalene green, O; patent blue, V A; fast blue, O R; fast blue black, O; deep black, G; azo yellow, victorine yellow, orange No. 2, fast brown O, ponceau G R R R, fast red O, Bordeaux G B R.

3. An acetic solution. Dyes, Bengal pink G B, phloxin G O, rosolan O B O F, rhodamin O 4 G, eosin A G, erythrosin.

By appropriate mixtures of the dyes of any one class, plumes can be dyed every possible color. After dyeing they are rinsed, and dried in a rotating apparatus. The final process is that of curling, which is done by turning them round and round over a gentle heat. For white feathers a little sulphur may be burned in the fire, for black or colored ones a little sugar.

A new and as yet little known method gives especially fine fancy effects with feathers. The solution of the dye to be used is put into an atomizer, and the spray directed to that part of the feather which it is desired to color. By using different colors the most marvelous effects and most delicate transitions from one color to another are obtained. Any kind of an atomizer can be used, the rubber bulb, pump, or bellows; the result is the same. It may be mentioned that atomizers are extensively used in many branches of industry, one instance in particular being in the manufacture of a certain kind of illustrated postal card.

THE DEAD, OR MATT, DIP FOR BRASS.

THE dead dip is the one which is used to impart a satiny or crystalline finish to the surfaces of ornamental brass articles. The bright dip gives the smooth, shiny, and perfectly even surface, but the dead dip produces a surface which is most beautiful. When properly done there is just enough life to it to give a pleasing appearance, but yet not sufficient to give false light reflections like a highly-polished surface. It is by far the most pleasing of any dip finishes, and can be used as a base for many secondary finishes.

Concisely speaking, the dead dip is a mixture of oil of vitriol (sulphuric acid) and aqua-fortis (nitric acid) in which there is enough sulphate of zinc (white vitriol) to saturate the solution. It is in the presence of the sulphate of zinc that the essential difference between the bright and the dead dip exists. Without it the dead or matt surface cannot be obtained.

The method generally practised in making up a dead dip is to add the sulphate of zinc to the mixed acids (sulphuric and nitric) so that some remains undissolved in the bottom of the vessel. At first thought this would seem satisfactory, but upon giving it further consideration it will be found that the sulphate of zinc occurs in small crystals having the appearance of very coarse granulated sugar. These crystals readily settle to the bottom of the vessel and do not do the work of matting which is required of them. If they are finely pulverized, the dip is slightly improved, but not as much as is frequently desired. It is impossible to pulverize such material to a fineness that will do the desired work. The use of sulphate of zinc, then, leaves much to be desired.

The most modern method of making up the dead dip is to produce the sulphate of zinc directly in the solution and in the precipitated form. It is well known that the most finely divided materials are those which are produced by precipitation, and in the dead dip it is very important that the sulphate of zinc which is in it shall be in a finely divided condition, so that it will not immediately settle to the bottom of the vessel. If the sulphate is precipitated as subsequently desired it will be produced in the very finest kind of a precipitate, so that when it is mixed with the acids it will not settle immediately. The method of making the sulphate of zinc directly in the solution is as follows:

Take 1 gallon of yellow aqua-fortis (38 deg.), and place in a stone crock, which is surrounded with cold water. The cold water is to keep the heat, which is formed by the reaction, from evaporating the acid. Now add metallic zinc in small pieces at a time until the acid will dissolve no more. The zinc may be in any convenient form—sheet clippings, lumps, granulated, or any other shape which is such that it may be added little by little. If all is added at once, the action is so violent that it will boil over. When the acid will dissolve no more zinc, it will be found that some of the acid has evaporated by the heat, and it will be necessary to add enough fresh acid to make up to the original gallon. When this is done, add one gallon of strong oil of vitriol. The mixture should be stirred with a wooden paddle while the oil of vitriol is being added.

As the sulphuric acid is being added, it will be noticed that the solution begins to grow milky, and finally the whole has the consistency of thick cream. This is caused by the sulphuric acid (oil of vitriol) precipitating out the sulphate of zinc. Thus the very finely-divided precipitate of sulphate of zinc is formed. If one desires to use known quantities of acid and zinc the following amounts may be taken: Oil of vitriol, 1 gallon; aqua-fortis (38 deg.), 1 gallon; metallic zinc, 6 ounces.

In dissolving the zinc in the aqua-fortis it is necessary to be sure that none remains undissolved in the bottom, as this would spoil the results.

The dead or matt dip is used hot, and, therefore, is kept in a stone crock surrounded with hot water. To use it, the articles to be matted are polished and cleaned in the usual manner and the dip thoroughly stirred with a wooden paddle so as to bring up the sulphate of zinc which has settled to the bottom. Now dip the work in the solution and allow it to remain until the requisite matt is obtained. This is a point which can be learned only by experience. When the brass article is first introduced, there is a rapid action on the surface, but in a few seconds this slows down so that there is scarcely any. Now remove the article and rinse and immediately dip into the usual bright dip. This is necessary for the reason that the dead dip produces a dark coating upon the surface, which, were it left on, would not show the real effect or the color of the metal. The bright dip, however, removes this and exposes the true dead surface.

The usual rule for making up the dead dip is to use equal parts of oil of vitriol and aqua-fortis; but these may be altered to suit the case. More oil of vitriol gives a finer matt, while a larger quantity of aqua-fortis will give a coarser matt. When the dip becomes old it is unnecessary to add more zinc, as it never requires it, on account of a little going into the solution each time anything is dipped. After a while, however, the solution becomes loaded with copper salts, and should then be thrown away.

A new dip does not work well, and will not give good results when used at once. It is usual to allow it to remain overnight, when it will be found to be in a better working condition in the morning. A new dip will frequently refuse to work, and the addition of a little water will often start it. The water must be used sparingly, however, and only when necessary. Water, as a usual thing, spoils a dead dip, and must be avoided. After a while it may be necessary to add a little more aqua-fortis, and this may be introduced as desired. Much care is needed in working the dead dip, and it is something that requires constant watching and experience, if uniform results are to be obtained. The chief difficulty in working the dead dip is to have to match a given article which is brought in to the dipper. No difficulty is found in producing the dead dip, if the solution is made up properly; but to have to match what is on a sample that has been submitted is one that tests the skill of a dipper more than anything else. The only way that it can be done is to "cut and try," and add aqua-fortis or oil of vitriol as the case requires.

The dead or matt dip can be obtained only upon brass or German silver. In other words, only on alloys which contain zinc. The best results are obtained upon yellow brass high in zinc.—Brass World.

PRACTICAL DIRECTIONS FOR THE RESTORATION OF OLD PRINTS.

SURPRISING results are obtained from the use of hydrogen peroxide in the restoration of old copper or steel engravings or lithographs which have become soiled or yellow, and this without the least injury to the picture. The cellulose which makes the substance of the paper resists the action of ozone, and the black carbon color of these prints is indestructible.

To remove grease or other spots of dirt before bleaching, the engravings are treated with benzine. This is done by laying each one out flat in a shallow vessel and pouring the benzine over it. As benzine evaporates very rapidly, the vessel must be kept well covered, and since its vapors are also exceedingly inflammable, no fire or smoking should be allowed in the room. The picture is left for several hours, then lifted out and dried in the air, and finally brushed several times with a soft brush. The dust which was kept upon the paper by the grease now lies more loosely upon it and can easily be removed by brushing.

In many cases the above treatment is in itself sufficient to greatly improve the appearance of the picture. In the case of very old or badly soiled engravings, it is followed by a second, consisting in the immersion of the picture in a solution of sodium carbonate or a very dilute solution of caustic soda, it being left as before for several hours. After the liquid has been poured off, the picture must be repeatedly rinsed in clear water, to remove any remnant of the soda.

By these means the paper is so far cleansed that only spots of mold or other discolorations remain. These are now removed by hydrogen peroxide, in a fairly strong solution. The commercial peroxide may be diluted with two parts water.

The picture is laid in a shallow vessel, the peroxide poured over it, and the vessel placed in a strong light. Very soon the discolorations will be seen to grow paler.

If after a few hours there is no further change, the liquid is poured off and replaced by a fresh solution, which is again left until its effect is exhausted.

By repeating this process as many times as necessary, the prints may be made to look as fresh as if just from the press. In the course of the long continued treatment with liquids, the paper will swell and curl, and great care must be exercised in drying. After partial drying in the air, it is placed between several sheets of blotting paper, put under a weight and left untouched until it has become dry. Only in this way can it be made perfectly smooth.

Colored prints (painted with water colors) cannot, of course, be cleansed with hydrogen peroxide, since this destroys all organic coloring matter. Treatment with benzine is often remarkably successful in such cases, where the pictures have suffered from dust or smoke. But it must be remembered that many organic substances are dissolved by benzine, and it is therefore advisable to make sure beforehand by experiment whether the water colors with which the print has been illuminated are of such a nature. If so, the picture cannot be cleansed without injuring the colors.—Dr. Josef Bersch in Neueste Erfindungen und Erfahrungen.

MAKING CARBON RODS AND PLATES.

By the Late GEORGE M. HOPKINS.

CARBON rods and plates of the finest quality can be made economically only by the use of expensive machinery and apparatus, such as pulverizing mills, hydraulic presses, and retorts or ovens; but the amateur, without a great deal of trouble, and with very little expense, can make carbon plates and rods which will answer a good purpose. The materials required are coke, wheat flour, molasses or sirup, and water. The tools consist of a few molds, a trowel or its equivalent for forcing the carbon mixture into flat molds, tubes to be used as molds for carbon rods, and ramrods for condensing the material in the tubes and forcing it out, and an iron mortar or some other device for reducing the coke to powder.

Clean pieces of coke should be selected for this purpose, and such as contain no volatile matters are pre-

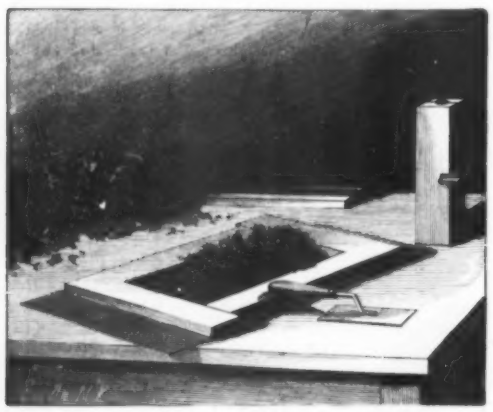


FIG. 1.—MOLDING CARBON PLATES.

ferred. The coke is pulverized and passed through a fine sieve. It is then thoroughly mixed with from one-sixth to one-eighth its bulk of wheat flour, both being in a dry state. The mixture is moistened with water (or water with a small percentage of molasses added) sufficiently to render it thorbughly damp throughout, but not wet. It should now be allowed to stand for two or three hours in a closed vessel to prevent the evaporation of the water. At the end of this time the mixture may be pressed into molds of any desired form, then removed from the molds and dried, slowly at first, afterward rapidly, in an ordinary oven at a high temperature. When the plates or rods thus formed are thoroughly dried, they are packed in an iron box, or, if they are small, in a crucible, and completely surrounded by coke dust to exclude air and to prevent the combustion of the plates or rods during the carbonizing process. The box or crucible must be closed by a non-combustible cover and placed in a furnace or range fire in such a way as to cause it to be heated gradually to a red heat. After the box becomes heated to the required degree, it is maintained at that temperature for an hour or so, after which it is removed from the fire and allowed to cool before being opened. The rods or plates are then boiled for a half hour in thin sirup or in molasses diluted with a little water. They are again baked in an ordinary oven and afterward carbonized in the manner already described. This latter process of boiling in sirup and recarbonizing is repeated until the required density is secured.

As some gases are given off during carbonization, it is necessary to leave the box or crucible unsealed to allow these gases to escape.

Fig. 1 shows an inexpensive form of mold for flat carbon plates. It consists of two right-angled pieces of wood of the thickness of the carbon plate to be made, and a thick plate of sheet iron. The iron should be oiled or smeared with grease before the mold is filled. The carbon and flour mixture is pressed into the mold smoothly, the wooden pieces are removed, and the carbon is left on the iron plate to dry. When dry, it is easily separated from the plate and may be handled without danger of breaking.

Cylindrical carbon rods may be formed in a wooden mold, as shown in the background of Fig. 1, and dried in a grooved iron plate adapted to receive them, or a brass tube may be used as a mold, as shown in Figs. 2 and 3. To facilitate the filling of the tube, a funnel may be formed on or attached to one end. The tube may be filled with carbon entirely from the top, or it may be partly filled by forcing its lower end several times down into the carbon mixture, finishing the fill-

FIG. 2.—MOLDING CARBON RODS.

ing at the top. The lower end of the tube is placed on an iron plate and the contents are rammed from time to time during the filling operation. When the tube is filled, it is discharged in the manner illustrated by Fig. 3, i. e., by pulling it over a fixed rod while its discharge end delivers the carbon cylinders to the iron plate on which they are to be dried and baked preparatory to carbonization. The plate in this case should be oiled to prevent the adhesion of the rods. The rod by which the contents of the tube are ejected should be on a level with the top of the iron plate. Fig. 4 shows in section an iron box containing plates and rods packed ready for carbonization.

NOTES ON THE CAUSES OF ACCIDENTS TO SUBMARINE BOATS AND THEIR SALVAGE.*

By CAPT. R. H. BACON, R.N., D.S.O.

THE reason for asking your indulgence in listening to this paper to-night is to place before you clearly the main causes of possible accidents to submarine boats, as well as the practical procedure of preventing their occurrence, and also incidentally to discuss certain considerations as regards the methods of raising such vessels in the event of accident. The whole matter of submarine navigation, and of the capabilities of the boats, is so little understood that widespread misconceptions exist, both as to the nature of the accidents that have occurred, and also as to the relative chances of accidents happening to these boats compared with service craft. By this discussion I hope the exaggerated idea of the dangers incident to the use of submarine boats which is prevalent among those not actually acquainted with their practical working will be done away with, and also that several fallacies existing in the public mind may be removed.

The details of the submarine boats which we use, and the tactical results we obtain, are very properly kept confidential by the Admiralty. But the broad questions we will touch on to-night deal solely with the one point of the prevention of accidents to them; this, far from being confidential, is a matter rather of common humanity. I am sure you will agree with me when I say that any accident in peace time, which involves loss of life, is a cause for regret to the whole civilized world, independent of the nation to whom it occurs; and speaking for those of us in the navy who are more particularly concerned with the running of these boats, I can assure you that when the late sad loss of the "Farfadet" occurred, fellowship of common experience gave us a true feeling of sympathy and sorrow only second to that which would have been caused by a similar occurrence nearer home.

It is not necessary to enter into detail as regards the design of submarine boats. I will assume that the broad principles, lately so ably dealt with by Sir William White, are known to you all. But it is necessary to accentuate the fact that every boat designed is designed to fight. They are no mere playthings, not merely structures of scientific interest. They have an important rôle to perform in war, and must be designed with that sole object in view. The test of excellence of design must be, that the boats shall be the best from the tactical and fighting point of view that is compatible with safety under all conditions of service, provided reasonable care is exercised.

To attain this the boats must be simple, and all complicated so-called safety devices must be avoided, most of which require the construction of specially dangerous boats to carry them, and above all things no secondary complications must be introduced to guard against primary defects, but these primary evils must be found out and eliminated. There would be no difficulty in designing a mere submarine boat with a maximum of safety devices, but with the minimum of fighting efficiency. It is here that judgment in design must step in. Broadly speaking, there are two classes of accidents that can happen to a submarine boat. First, the admission of water into the interior; secondly, an explosion. Both these have their counterpart in surface vessels, namely, collision and boiler or ammunition accidents. But the confined space and small reserve of buoyancy of the submarine boat intensify the danger of the result to the crew. And it is this, rather than the frequency of accidents, that has occasioned public comment.

In the case of admission of water, no help can be expected from water-tight bulkheads, for obviously to keep the vessel afloat each compartment must not have a greater capacity than the equivalent of the reserve of buoyancy; but, further, for such compartments to be effective, only one, namely, the center one, can be allowed the same volume as the reserve of buoyancy, since it is not only necessary to float the boat, but also to afford egress to the crew, and, therefore, the boat must be maintained approximately on an even keel. To do this no compartment except the midship one must exceed in capacity half the reserve buoyancy of the boat; this limitation is necessary so as to allow of a corresponding compartment, the opposite end of the boat being flooded to maintain the horizontal trim. Such subdivision would mean at least thirty compartments, and none except the one in the center of the boat could be more than 3½ feet between the bulkheads. Of course such a subdivision is an impossibility. It may, however, be argued that it would be well to have one or two compartments so as to confine the water to definite portions of the boat, and to leave a certain amount of space for the crew to inhabit in case of accidents. This is a very reasonable contention, but before accepting it we must consider the probabilities of an accident happening, the chances of such an accident occurring in waters where salvage is possible, and, further, the chances of successful salvage to save life under ordinary conditions of sea and weather; all these must be balanced against the ever present inconvenience in daily life of having the boat divided into these three or four compartments. Such subdivision is not merely an inconvenience as regards control and communication, but for another reason it reacts against the efficiency of the boat when actually running on service. One marked feature in practice is the way in which spaces below a certain size affect the normal mental condition of the men. To run a boat successfully everyone inside her should be in an absolutely normal condition; the increased constriction of vision and the necessary accuracy of handling argue even greater coolness than in ordinary vessels. For a man's mental condition to be normal, free living space is required; too confined surroundings react on the crew, and by producing a feeling of restriction create a mental tension; hence unless some very strong reasons exist for making living spaces below more confined than absolutely necessary they should be as large as the boat will permit.

The probabilities of accidents.—Taking first the case of water entering the boat. Two broad conditions exist when this is possible. One, where water enters a hatch, the other when it enters through a leak. The former is by far the more probable cause of such an accident. Of the four serious accidents whereby boats have foundered in the last few years, in fact, all modern accidents, namely, the Russian "Delfin," the French "Farfadet," "A1" and "A8," all have been due to water entering the hatch. The fact of the hatch being the main source of weakness is very suggestive, and most reassuring as regards the safety of the boats, since with the practical elimination of this source of danger the main cause of accidents up to the present will be obviated; in fact, if no other remedies were taken the attention attracted to this point should alone be sufficient to prevent accidents of this nature hap-

FIG. 3.—DISCHARGING THE MOLD.

FIG. 4.—CARBONIZING BOX.

pening in the future. Many suggestions have been put forward for operating such a hatch automatically, but no matter requires more careful consideration than suggestions for the automatic or semi-automatic closing of vital hatches, since if any portion of a man, either body, hands, or arm, is in the way, and is caught by the hatch, the aperture can never subsequently be made watertight, and the danger to the boat is greatly intensified. The simplest method of making the hatch of a submarine boat automatic is by hinging it on the foreside, so that the pressure of the water with the boat going ahead closes it, but had this been the case in "A8" there is little doubt that the captain, who was leaning across the tower, would have been caught, and

* Read at the summer meeting of the forty-sixth session of the Institution of Naval Architects.

every subsequent chance of stopping the water entering would have ended. The best method seems to be to hinge the hatch so as to open athwartships so that with headway on the boat no direct pressure to open or close it is exerted by the water, but should the tower submerge the lateral inrush will undoubtedly shut it. But let us for a moment analyze the chances of the water ever reaching the hatch.

The following is the broad outline of the previously-mentioned accidents so far as we know from the general accounts available: In the case of the "Delfin," the hatch was quite low, too large a number of men were in the boat, the ballast tanks were flooded while the hatch was open—an original and deadly error—the boat sank deep until the water lapped over into the boat. Such an occurrence should without doubt never have happened. No structural provision could ever forestall such an accident. In the case of the "Farfadet," the boat was apparently diving with the hatch improperly shut, and in attempting to close it fully, the hatch opened. In the case of "A8," the boat was being run with about one-third her normal buoyancy at considerable speed when she dived under, and her hatch was not closed by those near it.

Now, all these cases are of a nature that should not occur again, there is nothing inherent in submarine boats to render any of them liable to recur. In the case of the "Delfin," systematic drill and the most elementary care would absolutely preclude a repetition of such an accident. With the "Farfadet," a re-designed closing method would allow of tightening the hatch with safety. With "A8," the maintenance of full buoyancy when steaming fast would have prevented the water ever approaching the hatch 11 feet above the water-line. So far, therefore, we may legitimately state that these accidents are not such as in any way to destroy confidence in the general system of submarine work.

We have now to consider the question of the admission of water due to collision or grounding. As regards the former a collision of any magnitude must be a most serious matter; the reserve buoyancy in the boats is so small that even a small leak must be a very difficult matter to deal with. Watertight compartments have been shown to be out of the question, and, therefore, at all hazards collisions must be avoided. This being the case, it is the natural duty of a submarine boat to get out of the way of any craft that may do her damage. Such is only wisdom on her part, and with one craft determined to avoid, the chances of collision are greatly reduced. There is one point, however, greatly in favor of submarine boats, namely, the enormous strength of their structure compared with surface boats of similar tonnage; this is of the greatest importance in all minor collisions. Two cases are on record where the boats have been struck by the propeller of a ship and have been none the worse, and many cases of collision with other minor surface craft have left the submarine absolutely unaffected, whereas the surface craft have been seriously damaged. In the particularly sad case of "A1," the conning tower was struck by a large ship, and the hatch slightly sprung open; the structure otherwise was undamaged. The boat then traveled the whole length under the ship's bottom, during which time sufficient water had leaked in to prevent the boat subsequently rising. A watertight hatch now fitted at the base of the tower provides a means of guarding against any moderate leakage from such damage to the conning tower. Of course, should the hull of the boat other than the conning tower be damaged anywhere above the center line, then grave danger exists, and no considerations of design can save the boat against a considerable leak in such a position. This, however, is the one and only source of real danger to a submarine boat in event of collision, and the only reasons why it is greater in her case than in that of surface craft are the impossibility of fitting watertight compartments, and the short time available before her buoyancy is destroyed. This naturally leads us on to the consideration of what the reserve of buoyancy should be in a submarine boat. It is not permitted to discuss the design of boats, but it is infringing no secret to point out that the increase of reserve of buoyancy in the surface condition means increase of skin area for the same submerged displacement, and therefore for the same submerged horse-power. Storage of electrical power is extremely weighty, being for equal radius of action over thirty times that of the surface propulsion; for this reason only it is advisable, therefore, to keep the reserve buoyancy of the boats as low as is consistent with sea-going safety. No boat can be safer at sea than a submarine boat, since it is as tight as a bottle. No increase of actual safety is obtained by small increases in the reserve of buoyancy, say from 15 to 30 or 40 per cent, which entail other great disadvantages without *pro rata* gain. Provided, therefore, that the advantage gained in safety in case of collision by small increases in the reserve of buoyancy is very slight, and that the reserve is such as to insure seagoing safety, no object exists in reducing the efficiency of the boats from the fighting point of view, by increasing the surface reserve of buoyancy unnecessarily, and so decreasing their speed when submerged.

The other cause of danger, namely, grounding, is not so very great. There are two distinct conditions; the first, merely striking the bottom, which is amply provided for by practically the whole under surface of the boats being double-bottomed, as well as by the fact of the boats being buoyant, and so very considerably reducing the effect of a grazing blow. Danger of injury to the hull from this cause is really non-existent. The other possibility is of a boat sticking its nose into the mud. The sloping nature of the under side of the fore part of the boat does not assist such an occurrence probable, unless the boat were proceeding at a phenomenally large inclination, and even then the leverage exerted in getting rid of ballast, combined with the action of the propeller going astern, should exercise great influence in freeing the boat.

The last possible cause of water entering is from the boat diving to too great a depth, and the hull being crushed, or some of the hull fittings being unable to stand the pressure. This argues either the failure of the diving rudders, which are made as simple and as strong as possible, and should, therefore, be above suspicion, or that too much water ballast was being carried, and, therefore, that the boat would sink from

FIG. 2.

want of buoyancy. This actually occurred in the "Porpoise" in America. Fortunately the boat only sank in about 120 feet, the boat being built for 100 feet pressure. She, however, had the defect of having her tanks only constructed to stand a pressure of 25 pounds on the square inch, or, roughly, about 50 feet of water; the water in them could not therefore be blown out, since it was suicidal to attempt to admit the air pressure necessary to expel the water. The large pressure of water on the hull caused the boat to leak considerably, the electric pumps could not work against the pressure, and it was merely a race between the hand pump and the in-leakage of water whether she was ever raised to the surface or not. Providentially the hand pump gained the day, and the boat floated. In any boat every tank that can possibly be put into connection with the sea should be tested to the full hull resisting pressure. An accident such as this could not possibly occur with moderate care or proper design. The rate of blowing water from tanks is purposely made so great that a sinking boat should be caught and made buoyant long before a dangerous depth is approached. One turn of two handles, which are always kept in hand when the boat is diving, immediately relieves the boat of a large quantity of ballast.

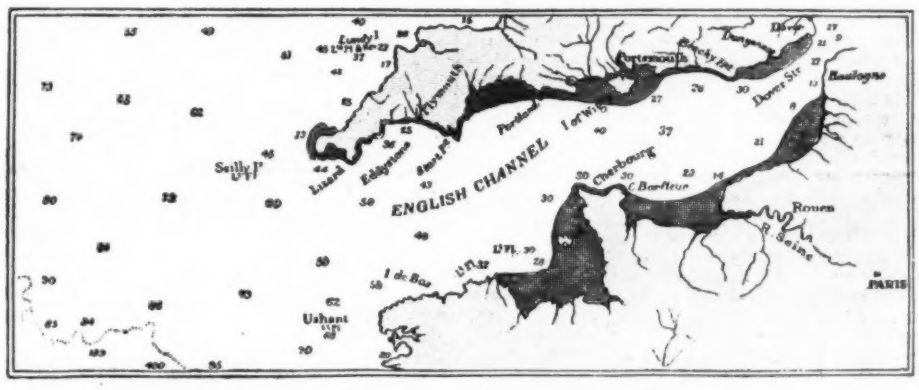


FIG. 1.—CHART OF THE ENGLISH CHANNEL.

Of all these possible causes of boats foundering from taking in water, we may fairly claim that the only one even probable is that when the boat is injured by collision in the hull above the center line.

Explosions.—The question of accidents from explosions inside the boat next claims our attention. Three causes of explosions only are possible, namely: (1) From an explosive mixture of petrol and air through a leak of liquid petrol into the boat. (2) From a mixture of hydrogen given off from the batteries during charge, or in discharge, if in case of accident the battery is flooded with water. (3) From the explosion of a compressed air reservoir.

As regards petrol, the main important consideration is, that to cause an explosion, first a leakage of liquid petrol is necessary, and secondly a spark is required to ignite the mixture. A leakage can invariably be detected by smell, should it occur; but in a properly designed system leaks should be practically non-existent. Even with vapor in the boat no direct danger exists, provided the boat is properly ventilated, and no switch is moved, or anything is done to cause a spark. As a matter of fact, in practice the smell of petrol inside a boat is almost unknown. In the case of

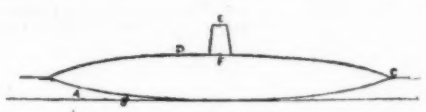


FIG. 3.

the accident to "A 5," where a petrol explosion occurred, the cause of the leakage was a badly packed gland of the petrol pump, the gland being screwed down metal to metal; but, in spite of one man being overcome by the petrol fumes, the main motor was started, and the sparks determined the explosion. Had the very explicit and simple regulations provided been carried out, no accident would have occurred. The boats are particularly free from all chance of accident with the engines at work, since the volume of air used every two minutes is equivalent in volume to that of the whole air of the boat; with such enormous ventilation going on, no chance of vapor accumulating is possible. A prevalent idea is that the petrol tanks are themselves a source of danger. A moment's consideration will show that no danger from this cause can exist; since, whenever a closed vessel has petrol inside it, the inclosed air is saturated with vapor, and is therefore non-explosive. The tanks are constructed so that leakage is impossible, and many other precautions taken so as to minimize every source of possible leakage in the petrol system. The English boats have covered over 30,000 miles under their engines, and, with the exception of one small flash in an early boat, no explosion except that in "A 5" has occurred. This of itself is fairly good evidence of the safety of petrol when moderate care is exercised. The second possible cause of an explosion is due to hydrogen given off by the batteries in charging; but, as this operation is only carried out when the boat is opened up for ventilation, no danger exists. The formation of this gas, however, has considerable bearing on the installation of the battery, and limits the extent to which it can be made thoroughly water-tight, for no risks can be run of allowing an explosive mixture being formed inside an air-tight space. The explosion which occurred to "A8" two hours after sinking was most probably due to the formation of this gas. The third cause, namely, the failure of the air reservoirs, is merely mentioned as a possibility; no greater danger from this cause exists on board a boat than on board an ordinary ship, where such accidents are unknown. The usual periodic tests should fully suffice to insure these reservoirs being in a thoroughly safe condition. We may, I think, from the above short account assume that danger to the boats from explosions is really small, and not greater in comparison than the dangers which have attended the introduction of increased boiler and gun power in the navy as a whole.

Salvage.—The problems connected with the salvage of these boats differ from those usually met with, chiefly because the question of rapidity is, or may be, of vital importance as regards the possibility of saving life. This factor is usually absent from other salvage operations, and no question then exists about setting deliberately to work and conducting the operations upon sound principles. The danger anticipated by the old adage, "More haste less speed," truly applies to this as well as all engineering work. A most excellent and pithy summary of the difficulties attending this work was given a short time ago by the Civil Lord of the Admiralty in answer to a question in the House of Commons. Let us first consider the areas near home where salvage operations of the boats are possible. Fig. 1 shows a small scale chart of the English Channel with certain areas marked black; these are the only waters in which boats can sink to the bottom without having their hulls destroyed by the pressure of the water. Now, our boats navigate the whole waters of the Channel; their radius of action is considerable, and they act absolutely without regard to the depth of water under them. The A class of boats have passed out of the experimental stage, and have taken their places as part of the naval forces of the country. Their maneuver grounds are chiefly in the deeper waters, and it is therefore evident that considerations of rapid salvage are totally out of the question should foundering occur in the majority of the waters in which they work. The suggestion, therefore, for building special salvage craft for dealing with submarine boats when the boats mainly operate in waters where rapid salvage is impossible, is one that cannot for a moment be practically considered, even should the probable frequency of accidents warrant such action, which as a matter of fact it does not. The first question as regards salvage is to provide for the succor of the imprisoned crew. Hundreds of suggestions have been received on this subject; all have received careful consideration, but up to date not one has been capable of practical application. The labor of attending to the numerous suggestions is very great, but it is well worth the expenditure of trouble if only some day one single good idea is forthcoming, and really it is impossible not to be grateful to all who attempt, however crudely, to assist the work of the country.

Let us consider the two most common and plausible of these suggestions. Before adopting any special appliance or constructional complication, suggested solely from the point of view of saving life in accidents, two considerations should be fulfilled: First, the fighting efficiency of the boat must not be seriously affected by it, since the boats are designed primarily for

fighting and not for meeting with accidents; and, secondly, that such arrangements when introduced shall be efficient against all reasonable accidents that may happen. It is simple to design a boat to be safe against any particular accident; the impossibility lies in designing one safe against every accident. The commonest device for the release of a crew from a boat is that of providing an air lock and diving chamber, and a hatch that can be opened from the bottom of the air chamber, the pressure of air preventing the water entering when the hatch is open; the crew can then, one by one, dive out and come to the surface. Supposing a sufficient space devoted to such an arrangement, there are two considerations which militate against its success. The hatch must necessarily be in the bottom of the boat, but if an accident happens it is "even chances," even in the uncommon case where the boat is undamaged, whether the boat rests with its fore or after end on the bottom as shown in Fig. 2. It is, therefore, an even chance whether the men would, or would not, be able to use this means of egress. Again, it must be assumed that water is present in the boat, otherwise there is no reason that she should not come to the surface, and if this water is present it is again an even chance if the compartment can be got at from the interior of the boat. But further, even supposing this chamber could be used, we have still to consider the effect on the crew of the variation in pressure by suddenly rising to the surface from a considerable depth. It is common knowledge that under pressure the gases absorbed in the blood get compressed, and that sudden release of such pressure allows them to expand, producing large bubbles of gas in the blood, which cause breaks in its continuity; this is productive of the most serious effects on the system, so that, even if the men were able to find egress, in many cases their lives would not be saved. Since, therefore, this system cannot be safely used in deep water, not at all on a soft bottom, and unless duplicated and placed at each end of the vessel, it is useless with a small amount of water in the boat, and quite valueless with a large amount, it is not a fitting on which it is worth wasting much valuable weight and space. Another common suggestion is to provide a detachable chamber into which the crew may climb, which can be freed, and then will float to the surface. A few figures will dispose of the practicability of this idea. Allowing 1½ square feet of space for each man, eleven men will require 16½ square feet. If the chamber were made cylindrical the thickness would be 1¼ inches. It would have to be ballasted to keep it upright when floating, and, moreover, must float with a certain reserve of buoyancy to allow of the top being open even in smooth water for the egress of the men. This means that the cylinder would have to be at least 6 feet in diameter, and 7 feet to 8 feet high. This would be an enormous excrescence outside the boat, and greatly increase her submerged resistance, even if further fitted with fair-waters to relieve its circular shape, although increasing its size. Its dimensions would quite preclude the possibility of carrying it inside. In addition, the securing arrangements and water-tight doors would add considerably to its weight, and then, in the end, a collision, which is, after all, the most probable cause of accident, would be liable to put it out of gear. Any one who really considers carefully the difficulties of providing reasonable methods of exit for a crew will soon be convinced of the futility of such special arrangements. If I am betrayed into saying that some convenient form of diving dress seems to provide the greatest chance of ultimate success, I add an appeal to non-experts who have neither seen the open sea nor have any knowledge of diving dresses to spare us written suggestions on this subject.

Suppose a boat at the bottom in less than 120 feet of water, the difficulties of rapid salvage are immense. Friendly critics who look on the Channel as a smooth sheet of water would have their ideas rudely dispelled if they had to undertake practical salvage operations. The number of days when sea and swell are absent are remarkably few, the hours available owing to tides are scanty, and the amount of physical work that divers are capable of doing in deep water is remarkably little. These ever-present handicapping factors, combined with the hundred and one little difficulties and delays that crop up, soon cause hours to run into days, and difficulties, not known to the outside world, cause those who have never had such work to do to wonder where the difficulty lies. But it is useless to dwell further on this matter; let us pass to the actual salvage of a boat on the bottom. A boat on the bottom can be in one of two conditions—either with hull intact or with it damaged. In the former case the salvage is fairly simple, and merely consists in connecting a compressed air pipe to a socket in the hull, admitting compressed air, and blowing the water out. I must, in passing, take the opportunity of thanking the many people who have taken the trouble to write either privately or to the press suggesting the provision of such a fitting. But, needless to say, this has been provided from the very first inception of these boats. If, however, the boat is damaged, she can either be lifted bodily, or the leak may be stopped and the water blown out, when she will rise of her own buoyancy, or do so with but little assistance. In the first case a considerable weight will have to be lifted, and provided the weather conditions are favorable no difficulty should exist, but the operation cannot be done without considerable labor. We will imagine for a moment that there is a chance of saving life in the boat, although a leak exists. In this case it will be necessary to lift the boat not merely to the surface, but sufficiently above the surface to allow of the hatch in the conning tower being opened without the danger when the air pressure is relieved of letting the water rise in the hull sufficiently to drown the survivors. For this purpose center line-lifting bolts on the hull are not of much use, since the purchases shackled to them will come "two blocks" before the hull is above water. Strops made by large hawsers are more convenient, since the blocks can be kept at the side as low as the middle of the boat. Again, the blocks that must be used weigh close on half a ton each; these are most difficult for a diver to handle. I do not know if I am addressing many who have been practical divers; if not, I must ask you to take my word, as an old diver, as to the enormous difficulty of bringing an unwieldy weight of half a ton near to, and of shackling it on to a fixed point, such as an eyebolt. Bringing a hawser to the block is far easier; or even shackling the hawser to the block on the surface, and then sweeping it into place under the boat, is a far easier and more practical method. Fixed bolts, under certain conditions, such as that of a boat being very deep in the mud, may be valuable; but for a rapid salvage their utility is very problematic. Another point to be kept in mind is that the strength of the lifting gear to be used should be the sum of the weight of water in the boat and any full tanks, plus the displacement she has to be lifted to; moreover, the slinging has to be distributed, so as not to strain the boat locally, cause her to leak, and allow the imprisoned air to escape from the inside. The fact of lifting the boat above water necessitates the use of more than one lifting vessel so that the boat may rise between them. This necessitates mooring these craft in exact position before any work can be undertaken, otherwise the tide will vitiate all subsequent operations. After everything has been done that can be done on the surface the whole rapidity of the subsequent work depends on the tides and on the weather. To attempt to shackle on blocks below with the lighters rising and falling two feet or three feet is impossible, and to take the weight of the lift, except on a smooth day, is equally impossible on account of the strain that would be brought on all the gear. The sudden immersion of the lighters and the inertia of the submarine are, in a sea, bound to strain the gear many times more than the mere weight to be lifted. For all these reasons rapid salvage is almost an impossibility, however hard everyone may work. Whatever appliances are available, wind, sea, and tide will always be the determining factors as regards rapidity of work.

The mere salvage of a boat, when rapidity is not essential, does not even when in deep water present any great difficulty. It is, in fact, easier in the case of a strong structure like that of a submarine than with an ordinary ship. Moreover, the peculiar shape of the hull makes it possible to sweep hawsers underneath the ends even in waters where it would be impossible to work divers. It has been suggested from some sources that the Admiralty should keep their own salvage plant for the general use of the navy. This is no concern of mine, and one for the Admiralty only to consider, but if I had any weight in their counsels, I would most strongly advise their doing nothing of the sort. Any one who has been practically associated with salvage work knows that success depends largely in practical experience and constant practice. The mere plant is quite a secondary consideration, and easily obtained. Moreover, in all large salvage operations special gear has to be designed and built. Such appliances cannot be kept stored. The valuable asset to salvage companies is the experience of their divers and the constant practice that the mercantile marines of the world afford them. In such commercial enterprises the navy can never have a share, and our own service alone does not, thank goodness, provide sufficient accidents to keep the men thoroughly practised.

In conclusion, I hope that I have been able to put impartially before you the relative safety of submarine vessels compared to that of surface craft. That the danger of the work is apt to be exaggerated, I think you will all concede. That it requires constant care goes without saying, but with the exercise of such care, no apprehension need exist of a larger percentage of accidents than in other branches of the service. That with the increase in numbers of the boats accidents will occasionally occur is undoubted, for wherever large quantities of energy are stored in an easily available state, danger must exist, but that this is present to an exaggerated extent in the case of submarine boats is not a fact. Nowhere is the extent of possible danger known better than among those who man the boats, and nowhere would the idea of excessive liability to accident be more scouted. There is, however, another class of danger that may exist, though at present it does not do so, and that is, that, in the desire to avoid all risks, the efficiency of the boats may be reduced both by constructional limitations, and also by curtailing their practical maneuvering by subjecting them to work less stringent than that which simulates war conditions. Much better have no boats at all than allow such limitations to creep in. At present we can safely say that all the work the boats do is up to the full requirements of war training, and that neither of the two lamentable accidents to the boats has in any way detracted from the severity of the tactical work. The sympathy of the whole country with the sad fate of those splendid men, who, being volunteers, were the pick of the service, is apt to lead to exaggeration of the real danger of the work. It is rather outside the navy than in it that apprehension as to the safe use of the boat arises. If this paper has succeeded in putting the real facts in a more dispassionate light, I feel that the half-hour you have so kindly afforded me will not have been wasted so far as the interests of the country are concerned.—The Engineer.

INTERFERENCE IN WIRELESS TELEGRAPHY.*

By John Stone Stone.

Of the various problems which have been presented in the course of the development of wireless telegraphy none is of greater interest to the engineer, and none is of more far-reaching importance from the industrial and commercial standpoint, than that of rendering the receiving instruments of wireless telegraph stations immune from interference. The simplest solution of this problem is to cause each transmitter to send out its signals by means of persistent trains of simple harmonic waves of a frequency materially different from that employed by any other transmitter within operative range of the receiving station with which communication is to be maintained, and to make each receiver responsive only to persistent trains of simple harmonic waves of the frequency employed by the transmitter with which it is in communication. By this means the system is rendered selective and becomes a multiple system of telegraphy, permitting the operator at each station to select the station with which he wishes to hold communication to the exclusion of all the other stations. A number of messages may thus be transmitted simultaneously in a given region without interfering with one another.

Since the stray electromagnetic waves arising from lightning, etc., are not persistent trains of simple harmonic waves, but partake more of the character of isolated impulses, the receiver in such a system does not respond to such stray electromagnetic waves, and it is, therefore, also freed from interference which would otherwise arise from such sources.

The manner in which a transmitting station is made to develop persistent trains of simple harmonic electromagnetic waves of one frequency to the exclusion of waves of other frequencies, though simple in itself, in practice requires the strictest attention to certain details, and these may be best understood by the consideration of a concrete case, this being the manner in which these problems are usually presented to the engineer if not to the inventor.

The vertical oscillator in general consists of two parts, the elevated conductor *per se* and the devices through which it is connected with the earth. We shall here consider the relative simple case in which the elevated conductor is a straight cylindrical copper wire of length a and radius ρ. Both theory and practice show that the electrical vibrations in such a wire connected directly to the earth at its lower extremity correspond very closely to the transverse vibrations of a heavily-damped stretched string. If such a wire be charged to a high potential and be then permitted to discharge to earth, the electrical oscillations developed in it, and therefore, also, the electromagnetic waves radiated by it, will not be simple harmonic in type and will not be persistent. These waves will not, therefore, correspond to the sound waves given out by a tuning fork, but will be of the character of those given out by a heavily-damped violin string plucked at its center.

The fundamental of the waves given out by such an oscillator has a wave-length which very closely approximates four times the length of the wire, and this is accompanied by all the odd harmonics. The oscillations are so much damped by the energy drawn off from the oscillator by radiation as to make the resulting waves more nearly the equivalent of an impulse than of a sustained or persistent train of waves. If, however, the elevated conductor be not directly connected to the earth, but be connected to it through an inductance coil, both theory and practice show that its electrical vibrations correspond to the transverse vibrations of a heavily-damped stretched string with a mass attached to its center. The effect of the load at the center of the stretched string and of the inductance at the base of the vertical wire is to increase the persistency of the vibrations, to minimize the importance of the harmonics and to lower the frequency of the fundamental. It might, therefore, seem that in order to cause the vertical oscillator in question to radiate a persistent train of simple harmonic waves of a predetermined frequency, it would be sufficient to charge the vertical wire to a high potential and permit it to discharge to earth through an inductance coil of suitable dimensions. This, indeed, was the plan adopted in the first crude attempts to produce a selective system of wireless telegraphy; but it necessitates the use of waves of much lower frequency than that normally produced by natural vibrations in the vertical wire *per se*.

The degree of persistency of oscillations so obtained, however, is not as great as is required in practice. Such persistency as is obtained is gained at the expense of the amplitude of the current oscillations in the vertical and at the expense of the radiating power of the oscillator, the latter being *ceteris paribus* less for low than for high frequencies. Moreover, the spark in the vertical oscillator which normally dissipates an undue amount of the energy of the oscillations, has its resistance enhanced by the reduction of the amplitude of the current oscillations due to the presence of the inductance coil. This latter difficulty may in a measure be overcome at the expense of any increase of the energy supplied to the oscillator, by shunting the spark-gap by a condenser of large capacity. The discharge of the condenser across the spark-gap increases the current through the spark and thereby reduces its resistance and damping effect upon the oscillations. The damping effect of the radiation still remains, and

* Abstract of a paper read before the Canadian Society of Civil Engineers.

the persistency is still too much limited for practical purposes.

So far we have considered only the natural oscillations of the vertical oscillator which are produced by charging the elevated conductor to a high potential and then permitting it to discharge to earth. When, however, a high degree of persistency, a pure sine wave, and a great amplitude of oscillation are desired, the spark-gap is removed from the vertical oscillating circuit and a simple harmonic E. M. F. is impressed upon the vertical oscillator in its place. The resulting vibrations in the vertical oscillator are then forced simple harmonic vibrations. In order that they may be of great amplitude, the frequency of the impressed force is made to correspond to the fundamental of the vertical oscillator or to one of its harmonics, in which cases the reactance of the vertical oscillator is *nil*.

A simple arrangement for producing forced, simple harmonic vibrations in the vertical oscillator is shown in Fig. 1, in which G is an alternating-current generator, K is a key, P shows the connection to the terminals of the primary of a spark coil, S is a spark-gap between the terminals of the secondary of the spark coil, C_1 is a condenser, L_1 is an inductance, I_1 and I_2 are the primary and secondary coils of a high-frequency transformer, and E is the earth.

For the type of elevated conductor which we are here considering—i. e., a cylindrical copper wire of length a and radius ρ—the reactance of the elevated conductor *per se* is given with a degree of approximation ample for engineering calculations by the expression:

$$Z = Lv \cot \frac{na}{v} \text{ where } L = 2 \log \varepsilon \frac{4a}{\rho} - k, \text{ and where } k = 5.584 - 3.169\ (na/v)^2 + 0.3269\ (na/v)^4$$

for values of a between 0 and $\pi v/2n$.*

In these expressions, v is the velocity of light and n is the periodicity of the impressed force or $2\pi/T$, where T is the time of a complete oscillation. The reactance Z therefore vanishes when $n = 2\pi/T = (m\ \pi v/2a)$, where m is an odd integer. The wave-lengths corresponding to this condition are therefore $\lambda = v\,T = 4\,a/m$. The wave-length of the fundamental is therefore $4a$ and the harmonics are all odd.

For frequencies lower than that of the fundamental, the reactance is negative or a capacity reactance. For

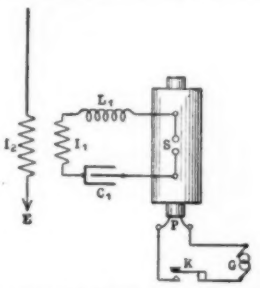


FIG. 1.—ARRANGEMENT FOR PRODUCING FORCED SIMPLE HARMONIC OSCILLATION.

frequencies between that of the fundamental and its first harmonic the reactance is positive or an inductance reactance. For frequencies between that of the first even harmonic and the first odd harmonic the reactance is again negative or a capacity reactance. In other words, the reactance of the vertical wire measured at the source or driving point of the system is either that of a condenser of capacity $S' = \frac{1}{Lvn} \tan \frac{na}{v}$ or of an inductance, $L' = \frac{Lv}{n} \cot \frac{na}{v}$ depending upon whether cot na/v is positive or negative.

The condition for zero reactance in the vertical oscillator system is obviously $Z + Z_0 = 0$ where Z_0 is the reactance of the apparatus connected between the vertical wire and the earth. Z_0 must therefore be an inductance reactance for frequencies which make the reactance of the vertical wire a capacity reactance and conversely it must be a capacity reactance for frequencies which make the reactance of the vertical wire an inductance reactance.

The curve shown in Fig. 2 gives the observed apparent capacity of vertical wires 0.08 inch in diameter varying from 40 feet to 180 feet in length, when the periodicity of the impressed force is 9.78×10^6. In other words, it gives the observed apparent capacity of vertical wires for values the angle of na/v from 0.3976 to 1.790, and for values of the ratio $4a/\rho$ from 47,520 to 213,800.

The reactance Z_0 of the apparatus through which the vertical wire is connected to ground may most simply be made negative, when this is necessary, by the insertion of a condenser in series with the coil I_2, but this result may be accomplished in a variety of ways, for the description of which there is not space in this paper. It will seem that by making $Z_0 + Z = 0$ or Z_0 equal but opposite in sign to the reactance of the elevated conductor, powerful oscillations of any desired frequency may be developed in the vertical oscillator by means of forced vibrations, whereas when the natural oscillations of the vertical oscillator are resorted to, the frequency must necessarily be less than that of the fundamental of the oscillator.

Concerning the arrangement illustrated in Fig. 1, there is much of detail which requires attention in order that the apparatus shall satisfactorily fulfill the requirements of radiating a persistent train of simple harmonic waves. For instance, if a dielectric having

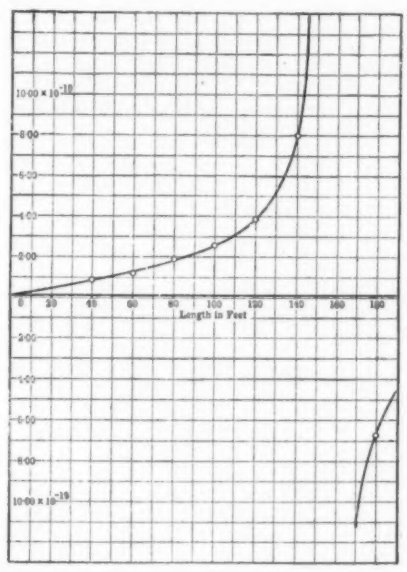


FIG. 2.—CURVE SHOWING RELATION BETWEEN APPARENT CAPACITY AND LENGTH OF ELEVATED CONDUCTOR AT PERIODICITY = 9.78×10^6.

considerable electrostatic hysteresis be employed in the condenser, a surprisingly large amount of energy will be dissipated in this dielectric. The magnitude of this loss is due to the fact that the energy dissipated increases both with the P. D. employed at the terminals of the condenser and also with the frequency. Since P. D.'s developed at the terminals of the condenser amounting to 50,000 volts and oscillations having frequencies of 5,000,000 are not unusual in wireless telegraphy, it is easy to see that the losses in the dielectric of a condenser in a wireless telegraph circuit are of a far greater order than that in the dielectric of condensers employed in the usual power or lighting circuits. Moreover, the specific inductive capacity of most dielectrics is a function of the density of the displacement current in the dielectric, and when such dielectrics are employed in the condenser in an oscillating circuit the resulting oscillations are not simple harmonic in form and are not isochronous throughout the train. Air condensers should, therefore, be used in wireless telegraphy to the exclusion of any other type.

The coils used in wireless telegraphy should not have iron cores except the iron be very finely comminuted and embedded in a non-hygroscopic dielectric matrix. It has even been found by the author that coils wound on a wooden cylinder do not operate satisfactorily when used in the oscillating circuits of wireless telegraphy. The coils for this purpose are best constructed by winding a few turns of bare copper wire in a single layer on a skeleton frame made of ebonite, care being taken to separate the turns by such an amount that the sum of the air spaces between the wires of the turns is equal to or slightly greater than the sparking distance in air corresponding to the greatest P. D. liable to occur at the terminals of the coil when the apparatus is in operation. If the local oscillating circuit $C_1I_1L_1S$ of the arrangement shown in Fig. 1 were isolated, its oscillations would be expressed by

$$i = e\sqrt{\frac{S}{L}}\varepsilon^{-\frac{R}{2L}t} \cdot \sin\frac{t}{\sqrt{LS}},$$

where i is approximately the current, e is the potential to which the condenser C_1 is charged at the time when

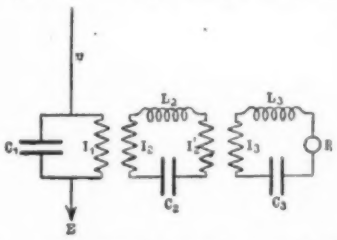


FIG. 3.—SELECTIVE RECEIVING CIRCUIT.

the spark occurs at S. L is the inductance of the circuit, R is the resistance, and S is the permittance or electrostatic capacity of the condenser.

The time required to fall to $1/\varepsilon$ of their initial amplitude is therefore $t = 2L/R$. The number of oscillations per unit of time is $1/2\pi\sqrt{LS}$. For a given frequency, $Ln = 1/Sn$, so that the persistency for a given frequency is proportional to Ln/R, where n is 2π times the frequency. The measure of the persistency of the circuit is, therefore, proportional to $\sqrt{LR^2\varepsilon}$.

An isolated circuit of this type may be made to give extremely persistent simple harmonic oscillations, but if it be given a large coefficient of mutual inductance with another oscillator of relatively low persistency, such as the vertical oscillator VI_2E of the arrangement shown in Fig. 1, two things happen. In the first place, the oscillations of the circuit are in general no longer simple harmonic, but are broken up into two simple harmonic oscillations of different frequencies, and in the second place the persistency is greatly reduced. To overcome this difficulty it is necessary either to make the magnetic leakage of the high frequency transformer, connecting the local oscillating circuit with the vertical oscillator, unusually large, or else to add to the local oscillating circuit an inductance coil L_1 with sufficient inductance to swamp by its effect the reaction from the secondary circuit. When intense radiation is desired, it is necessary to make the capacity S of the condenser C_1 in the local oscillating circuit large compared to S', the apparent capacity of the elevated conductor *per se* for the frequency employed.

Since the electromagnetic waves to be received at a wireless telegraph receiving station are horizontally polarized at the earth's surface, an electrical oscillator whose axis is normal to the earth's surface is employed at the receiving station. This oscillator may either be connected to earth at its lower extremity or it may be connected to a device having reactance equal for all frequencies to the reactance of the vertical oscillator. It is to be remembered in this regard that at the receiving station we are not concerned with what becomes of the energy which is dissipated by the reradiation of the energy from the receiving vertical oscillator.

We shall consider again a simple concrete case, and shall assume the elevated conductor to be a cylindrical copper wire of length a and radius ρ as in the case of the transmitter, though it must by no means be assumed that the elevated conductor at the receiving station must necessarily be similar to that at the transmitting station, or, in fact, that it must bear any resemblance to that at the transmitting station, except in so far as its axis is preferably normal to the surface of the earth.

As in the case of the transmitting station, only one simple arrangement of the apparatus sufficient to give

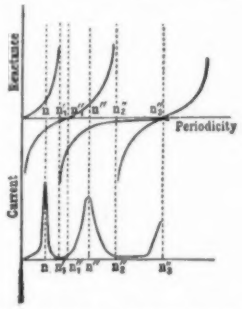


FIG. 4.—GRAPHICAL DEMONSTRATION OF SELECTIVITY.

the desired result will here be considered. By this arrangement messages transmitted by means of persistent trains of simple harmonic electromagnetic waves of a predetermined frequency may be received to the exclusion of messages transmitted by similar waves of materially different frequencies, and without interference by impulsive waves. Such an arrangement of the circuits and apparatus is shown in the diagram, Fig. 3. In this arrangement the receiving device which is indicated at R is placed in a local circuit, $C_2I_2L_2R$, made resonant to the frequency of the waves to which the station is intended to respond, and a second resonant circuit, $C_3I_3L_3I'_2$, resonant to the same frequency and called a "weeding-out circuit," is interposed between the first-mentioned circuit and the vertical oscillator. The branch circuit, consisting of the coil I_1 and the condenser C_1 is not, when taken by itself, resonant to the same frequency as the other local circuits, but is so proportioned that when connected as a branch circuit, forming a part of the vertical oscillator system, the latter shall respond most energetically to persistent trains of waves of that frequency falling upon the vertical wire. The way in which this is accomplished is perhaps more easily seen by a graphical demonstration than by the use of the analytical solution, though the latter is by no means difficult.

The curves in Fig. 4 illustrate the point in question. Curve 1 represents the reactance of the vertical wire measured at its point of attachment to the loop circuit, for varying periodicities of the impressed force. It will be seen that the periodicity of the fundamental of the vertical wire is at the point n_1'', where the reactance first vanishes. The first even harmonic is at n_2'', and the periodicity of its first odd harmonic is at n_3'', where the reactance again vanishes. Normally, therefore, curve 3, which is the current curve for varying periodicities of the impressed force on the vertical wire, would show maxima at n_1'' and at n_3''. The reactance of the loop circuit for varying periodicities of the impressed force measured across the points of its attachment to the vertical wire and earth connection is shown in curve 2. The total reactance of the vertical oscillator measured at the earthed terminal is the algebraic sum of the two reactances shown in curves 1 and 2, and as a result the current curve 3 shows maxima, not at n_1'' and n_3'', but at periodicities n, n'',

* The value of k here given has been determined empirically, the remaining [illegible] formula being based upon a theoretically deduced working theo[illegible] in the paper referred to. A more complete expression for [illegible] en elsewhere.

and at a periodicity slightly higher than n_2''. These are the points at which the reactance of the loop circuit is equal, but opposite in sign, to that of the vertical wire. The periodicity of the local loop circuit *per se* is n_1' and for this periodicity the current in the vertical wire is practically *nil*.

The "weeding-out circuit" and the circuit containing the receiver are both resonant to the periodicity n, so that for persistent trains of waves of that periodicity the energy of the oscillations set up in the vertical oscillator is transmitted directly to the receiver, but persistent trains of waves of other frequencies either produce but slight response in the vertical oscillator or else produce oscillations of the periodicity n'', or of a periodicity slightly higher than n_2''. To such periodicity the "weeding-out circuit," and the circuit containing the receiver are extremely irresponsive, so that the receiving device receives but an inappreciable amount of the energy of the waves. In the case of impulsive waves the vertical wire tends to respond only to its own natural rates of vibration as affected by the loop circuit, that is to say, it tends to oscillate at periodicity n'' and to upper harmonics. Such waves acting on the vertical wire, have little tendency to develop oscillations of the natural period of the loop circuit as affected by its connection with the vertical wire, namely n, and the receiver is therefore also protected from the effects of such waves.

All that has been said regarding the effects of electrostatic and magnetic hysteresis in the description of the transmitting station applies with added force to the apparatus at the receiving station. It is, in fact, much more important to exclude the effects of hysteresis from the receiving circuits than from the transmitting circuits, and it may be laid down as an important rule that under no circumstances shall solid or liquid dielectrics be used in the receiving circuits. Moreover, the injunction in regard to making the mutual inductance small between oscillators at the transmitting station applies in the case of the resonant circuits at the receiving station, since if the mutual energies of the related resonant circuits be not small compared to their self energies, the resonant circuits will modify one another's natural periods, and each circuit will respond to more than one periodicity. Finally, it may be said that the measure of selectivity of a resonant circuit is proportional to $\sqrt{L/R^2S}$, this expression being the same as that found in connection with the persistency of an oscillating circuit. For a given periodicity, therefore, the selectivity is proportional to LN/R. So great is the selectivity of resonant circuits constructed of air condensers and properly designed inductance coils that there is no difficulty in adjusting such circuits to resonance for a given frequency with an error of less than 1 part in 3,000. The importance of the "weeding-out circuit" at the receiving station becomes apparent when we observe that the selectivity of the receiving vertical oscillator is greatly diminished by the dissipation of energy, which results from the reradiation of energy by that oscillator, and that the selectivity of the resonant circuit containing the receiver may be greatly diminished by the energy absorbed by the receiver and utilized in its operation.

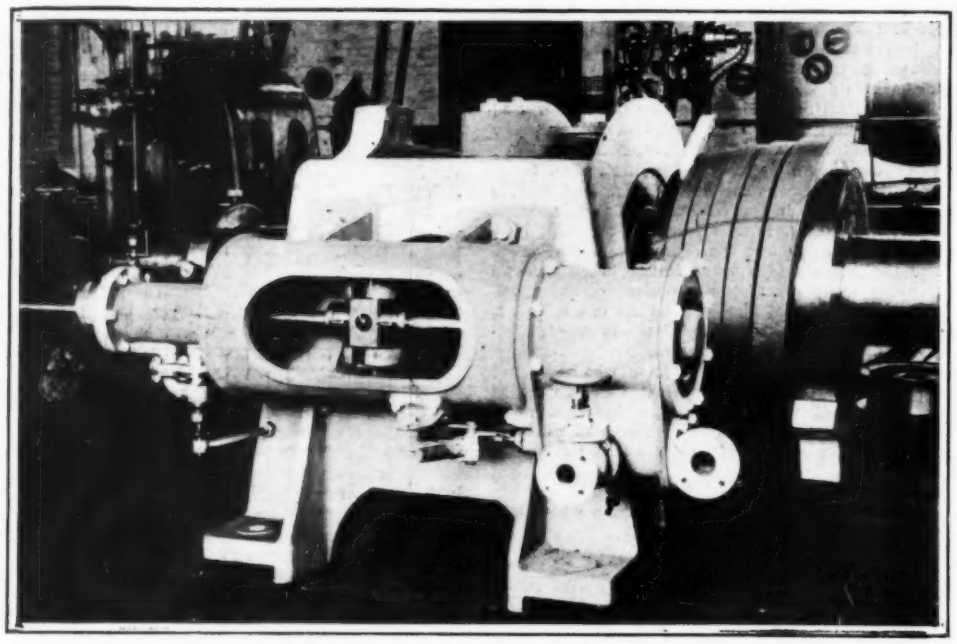
A NOVEL COIL-CLUTCH REVERSING GEAR.

By the English Correspondent of Scientific American.

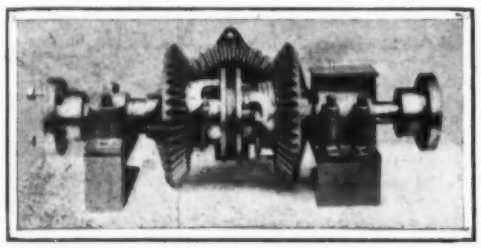
One of the greatest disadvantages attending the employment of large machinery is the power and time wasted in a reversal of the direction in which the machinery is running. Such operations necessitate the stopping of the machine and the restarting of the rotating masses. The larger the machine, the greater is the amount of power and time expended in the operation; and in a large machine, where reversals are frequent, the laborious task of stopping and restarting contributes in no small degree to the expense and time occupied in the completion of the undertaking. In some machines a reversing gear is provided between the engine and the rolls so that the former may run continuously in one direction, no matter in which direction the work may be passing through the rolls. Consequently, the energy stored in the flywheel of the engine is not wasted with every reversal, and a continuously-running machine so equipped has been proved to be capable of the same effective work as a reversing engine of nearly four times as great an indicated horse-power.

To obviate such disadvantages, an ingenious coil-clutch reversing gear has been placed on the market by the Consolidated Engineering Company, of Slough (England), and is especially valuable with large machinery such as rolling mills. A copper-rolling mill in France has recently been equipped with this attachment, and it has proved of great value, as the rolls are of 11 feet 6 inches width and 2 feet 9½ inches diameter.

The principle of this clutch is two steel coils surrounding drums keyed on to the shaft which has to be reversed. The outer end of each coil is fixed to a gear wheel loose on the shaft; these wheels are driven continuously in opposite directions, and carry the coils round with them. A sliding collar is placed on the shaft between the inner ends of the coils. This collar when moved in either direction comes into contact with a bell-cranked lever, and this tightens the last turn of the corresponding coil on the drum. All the coils grip the drum by the motion of the gear wheels, with the result that the shaft commences to revolve solidly with the wheel.



VIEW OF CLUTCH, SHOWING STEAM STARTING GEAR.

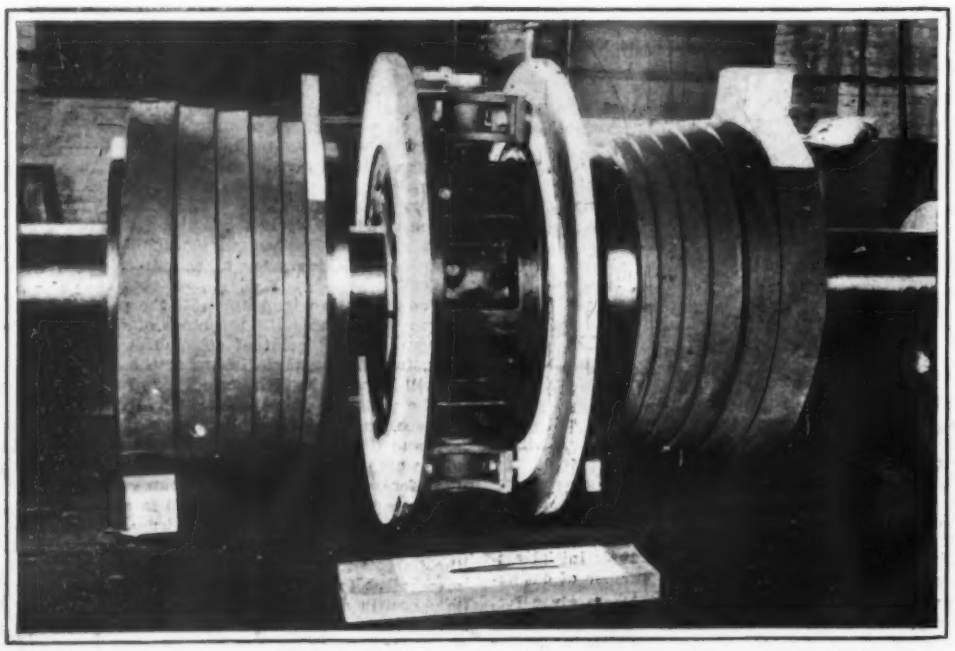


REVERSING CLUTCH APPLIED TO PROPELLER SHAFT OF POWER BOAT.

The accompanying photograph of the pair of coils and the central collar on the shaft shows distinctly the shape of the coils and the driving lugs. The drums on which the coils work are made of chilled cast iron 36 inches diameter, while the shaft is 16 inches diameter. This particular clutch, which is in operation at the French copper-rolling mill already mentioned, is the largest that has yet been constructed, and it has not only to effect the reversals of the rolls at 40 revolutions per minute, but has also to withstand the tremendous strain of pulling up the engine in the event of the rolls becoming jammed.

A pair of levers keyed to the central shaft effects the motion of the central collar for reversal. These with another pair of levers extend and engage with the crosshead of the steam reversing gear, the general appearance of which is shown in the second illustration. The cylinder has a diameter of 11½ inches by 10-inch stroke, and the admission of the steam is controlled underneath by a valve worked by rods from a hand lever which is conveniently placed. There is another cylinder filled with oil opposite the steam cylinder, the two ends of the former being connected by a by-pass. By shutting the by-pass the passage of the oil is stopped and the gear locked in any position without that end thrust which would result if steam were maintained in the reversing cylinder.

The mechanism is also applicable to the propeller shafts of power boats, and the third illustration shows a clutch fitted to the shaft of a 30-horse-power Diesel oil engine. The mechanism is practically the same as the large type, except that one chilled friction drum is common to both coils. The latter are fitted to the clutch bevel wheels, the crown wheel being merely idle for reversing the rotating direction of the second bevel wheel. The clutch wheel for forward driving is keyed upon the propeller shaft, while that for running astern runs loosely on the engine shaft. Consequently, in driving forward the drive is direct from one shaft to the other through the forward clutch, the wheels being free. In going astern the drive is transmitted through the wheels and the backward clutch. Either clutch is put into gear as desired by a hand wheel and screw gear working a lever which engages the sliding collar between the coils.



CLUTCH COILS AND SLIDING COLLAR ON SHAFT OF FRENCH COPPER-ROLLING MILL.

Electrical Radiography.—Gabritschwenski reports in the Physikalische Zeitschrift on peculiar pictures of articles by means of radium, which are obtained when there are placed on an electrified ebonite surface, besides radium, various objects, especially flat ones, and the latter as well as the radium are removed from the plate after about 10 to 15 minutes, sprinkling the surface with the mixture of sulphur and red lead used for the Lichtenberger figures. The pictures, which are red (electro-negative) in the case of an electro-negative plate, are very sharply outlined and improve the closer the article touches the plate, but an actual contact is not necessary to cause this phenomenon. The radium may also be a little away from the plate, even on the other side of it. With small and thin plates the images can be produced in three minutes. If only a portion of the plate is electric, and the radium lies on the other part, a yellow picture of the radium on a red field results.

THE ELECTRIC STEERING GEAR OF THE TURBINE STEAMER. "MANXMAN."

By the English Correspondent of SCIENTIFIC AMERICAN.

SOME months ago we described in the pages of the SCIENTIFIC AMERICAN the system of electrically steering a vessel that has been introduced by Messrs. Siemens Brothers & Co., Ltd., of London. The installation therein described had been installed upon the inventor's steam yacht. Recently, however, the first commercial application of the system has been carried out by the above firm in connection with the turbine steamer "Manxman," recently placed upon the Midland Railroad Company's Irish mail service.

This installation is a combination of steam and electric power, either being used as desired, and whenever it becomes necessary the ship can be steered by hand, there being a clutch for throwing the other two motive systems out of gear. The steering gear is of the general Admiralty pattern, placed at the stern of the vessel and connected direct to the rudder head. The gear comprises a steel spindle or shaft with a right and left handed screw, on which are mounted nuts connected by heavy levers to the rudder head. When the shaft is rotated in either direction by the screw, the nuts travel correspondingly, also actuating the levers and operating the rudder head. A heavy worm wheel geared to a worm driven through shafting revolves the shaft in either direction. The worm can be driven either by the steam gear, which is placed on the port side, or by the electric motor, which is mounted on the starboard side, while furthermore a system of electric control, connected both to the armature of the main electric motor and also to the valve of the horizontal steam engine, is provided.

The steam motive power is supplied by a horizontal steam engine of the Hastie type of simple construction. It has two cylinders with a stroke and bore of eight inches. The crank shaft of the engine is coupled to the worm shaft through a clutch, which enables it to be thrown in or out of action as desired. This worm shaft also has a clutch for throwing both steam and electric motion out of action, so that the vessel can be controlled by the hand wheel on the deck above.

The design and principle of the electrical equipment, which is the most interesting feature of the installation, can be comprehensively followed in the accompanying illustrations. On the navigating bridge are placed two hand steering wheels; one is simply mechanical in its action, while the second wheel is electrical in its operation. The former controls through bevel gearing, rods, and change gear a shaft in the steering engine house, and operates either the steam valve or the electric motion, while the second system

ELECTRICALLY-ACTUATED HAND STEERING WHEEL ON THE NAVIGATING BRIDGE.

actuates through a hunting switch, actuating motor, and cable the electric mechanism in the steering engine house. From this it will be seen that there are two systems of control from the bridge to each gear.

There is a vertical shaft operated by the electrical steering wheel on the bridge deck. This spindle extends through two decks to a hunting switch and controlling motor, which are placed somewhat distant from the bridge, so that all possibility of electrically influencing the compass is overcome. The hunting switch is one of the most interesting features of the installation. Its principle is demonstrated in the accompanying diagram. There is a disk, *A*, connected to the vertical shaft extending from the bridge steering wheel, while there is another disk, *B*, geared to the controlling motor. When the steering wheel is moved, thereby rotating the vertical shaft and its accompanying disk, *A*, current is transmitted to the controlling motor, and the resultant motion of the latter causes the disk, *B*, to revolve immediately after *A*. All the time the steersman is moving his wheel these two disks continue to revolve together, one hunting the other.

The hunting switch passes the current to an actuating motor, and this sets the main motor in action. When the navigator turns the wheel to starboard, he makes a contact at 3, 4*a*, and 4, and at 1 and 2, 1 being the resistance step. The introduction of the latter insures not only gradual continuation of the current, but furthermore reduces the spark of breaking. In connection with the breaking of the current a magnetic blowout is fitted on the switch. When the navigator sets the rudder in the opposite or port direction, he makes a contact at 3, 3*a*, and 4, and at 1 and 2 as before.

By referring to the diagram of connections, the principle of passing the current to the controlling and actuating motors may be followed. It will be observed that the reaction of the controlling motor upon the hunting switch controls the current not only to itself, but to the actuating motor as well. The controlling motor consequently has but one function—arresting the motion of the steering gear when desired. These two motors work synchronously in their operation, and their control is such that they rotate through an arc exactly corresponding to the extent of the revolution of the hand-steering wheel on the bridge.

The change gear from steam or electric drive in its position in the steering engine room on board the vessel, together with the actuating motor, is shown in our illustration. The actuating motor drives only through the change gear, by which its motion can be transmitted to the steam valve of the steam engine, or to a relay hunting switch controlling the main electric motor for actuating the rudder. This change gear can therefore be worked electrically from the electric steering hand wheel, or by the hand steering wheel and its mechanical action through rods and bevel gear. This is carried out by mounting the bevel wheels vertically. The upper and lower bevel wheels are both mounted on a sleeve, and are connected. By lowering them the electric gear is disconnected, and the hand gear brought into service. There are similar horizontal bevel wheels mounted on a sleeve and connected.

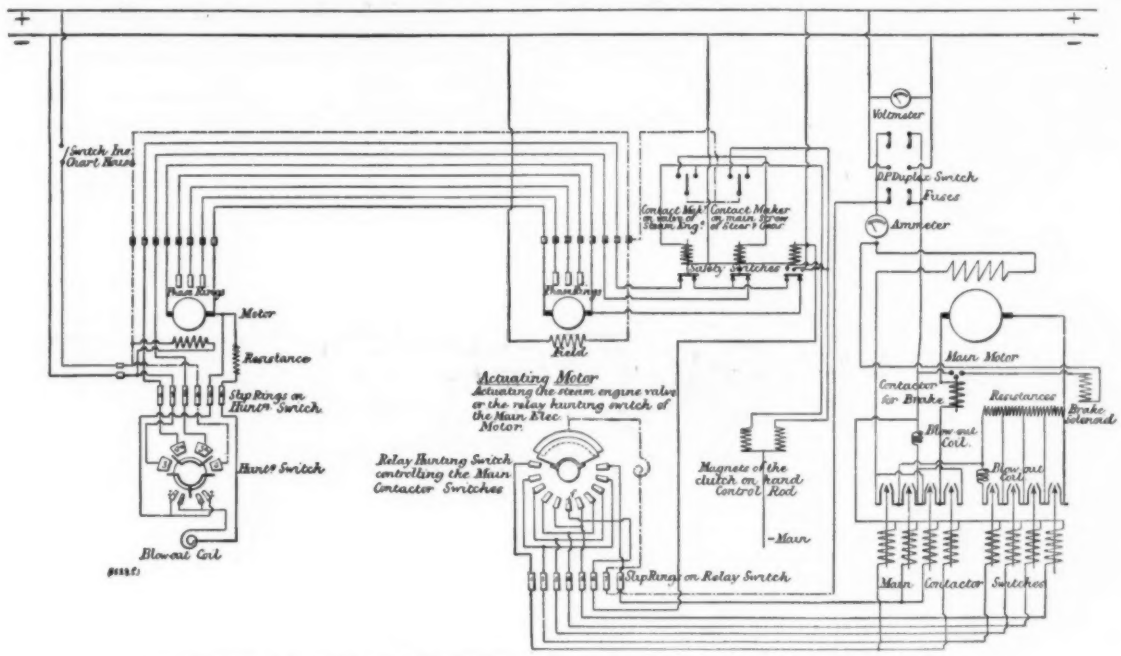
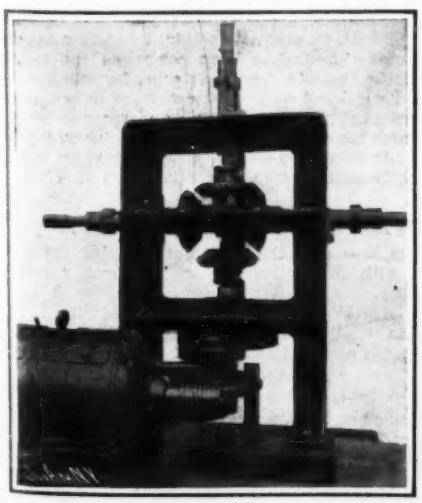
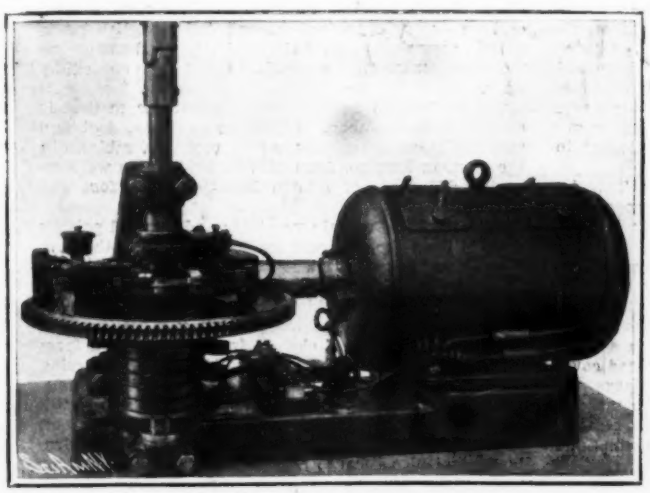


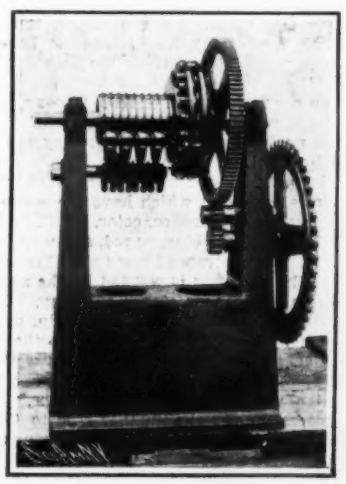
DIAGRAM OF THE CONNECTIONS OF THE ELECTRICAL STEERING GEAR.



MOTOR ACTUATED WITH CHANGE GEAR FROM ELECTRIC OR STEAM ENGINE.



HUNTING SWITCH WITH CONTROLLING MOTOR.



RELAY HUNTING SWITCH.

These have a free horizontal sliding motion, and their operation brings into action either the electric or steam motive power as desired. It will be realized that by this ingenious arrangement any possible combination is available, while there are three distinct methods of completing the identical function—steering of the ship.

The relay-hunting switch, which works in conjunction with the actuating motor, makes contacts with the solenoids of the main contactors, which are mounted on a platform abaft the steering gear. The current of the solenoids of the main contactor switches are controlled by the relay switch, while the contactor switches control the current of the main electric motor. There is a chain drive to the latter, which cuts off the current to the solenoids of the contactor switches directly the relay switch stops, being turned by the actuating motor. The relay hunting switch turns in of the solenoids of the main contactor switches is contactors, which give the direction of current to the motor armature, while the other contacts made by the relay switch cut out the main resistance from the motor.

The main contactors are similar in type to those used for multiple systems for railroads. They comprise solenoid switches, the cores of which being raised make contact across two heavy copper bars. There is a carbon break provided to each contact, and it is inclosed in an asbestos chute. Large-sized main resistances completely inclosed in water-tight casing are provided, while in addition there is a magnetic blow-out.

The main motor is of the inclosed ironclad type developing 40 horse-power, and capable of overloading safely up to 50 per cent. The motive power is transmitted to the steering gear through the shaft to which the steam engine is also connected. In order to insure the instant stoppage of the motor when the current is cut off, it is fitted with an electric brake. Brake blocks press upon the drum by means of spiral springs. These blocks are released when the current is again switched on to the main motor by a solenoid excited by the relay-hunting switch, coincidentally with the actuating of the solenoids of the contactor switches by the relay hunting switch.

This electrical steering gear has proved highly efficient on board the "Manxman," and its operation is being closely followed by marine engineers. The Admiralty have also decided to install it on board one of the second-class cruisers, and Messrs. Siemens & Co. are now erecting the apparatus.

MILK DANGERS AND THEIR AVOIDANCE.

The dangers that lurk in milk are due in part to human agency, conscious or unconscious, and in part to unfavorable natural conditions.

The adulteration of milk by skimming and the addition of water and other substances is punishable by law, and the ingenious methods and accurate instruments which have been devised to detect it restrict this evil, which is of less importance than the contamination of milk due to carelessness and ignorance.

Only recently has it been learned that cleanliness in the dairy improves the keeping qualities of milk. The crusade in behalf of cleanliness has produced marked improvement in some quarters, but there is still an unfortunate difference of opinion, especially in the rural districts, as to what constitutes cleanliness. A German veterinary journal gives the results of the examination by Ott of 55 specimens of milk, of which only 3 were found entirely clean. The average quantity of dry solid impurities in a liter was 0.028 gramme, corresponding to 0.138 gramme of fresh cow dung. In the milk of various German and Scandinavian cities, Prof. Jensen found from 0.002 gramme to 0.015 gramme of impurities to the liter, the smallest amount occurring in Helsingfors. Our legal requirements in this respect are very moderate. In Dresden, for example, 0.008 gramme of impurities per liter is permitted.

Milk which deposits no visible sediment after standing two hours in a glass vessel may be regarded as clean.

Now, it should be remembered that animal excrement contains bacteria, to the number of 375 millions in a cubic centimeter, which spoil milk and make it unfit for food.

Milk also contains great numbers of other microscopic organisms. Some of these, the non-pathogenic microbes, are neither injurious nor beneficial. Others, called saprophytes, destroy the pathogenic bacteria and are, therefore, of positive benefit. Toward another group our feelings are mixed. These are the lactic acid bacteria which cause the souring of milk. They are often useful in the dairy, but they are a nuisance to the housewife in summer.

The next group is far more unwelcome. This includes all bacteria which have the common property of altering the appearance, color, smell, and taste of milk, making it yellow, blue, or red, slimy or "ropy," bitter or putrid. Such advanced cases are of rare occurrence, because the producer is warned by the appearance of the milk in the earlier stages of decay. But milk which does not yet bear the mark of Cain, so to speak, may swarm with microbes poisonous to the human system. In a cubic centimeter of milk from well-groomed cows, Hueppe found 20,000 germs, of which a very large proportion were of poisonous character. In the milk of ungroomed cows the number rose to 170,000. Most of the poisonous microbes occur in strings or chains and are known as streptococci.

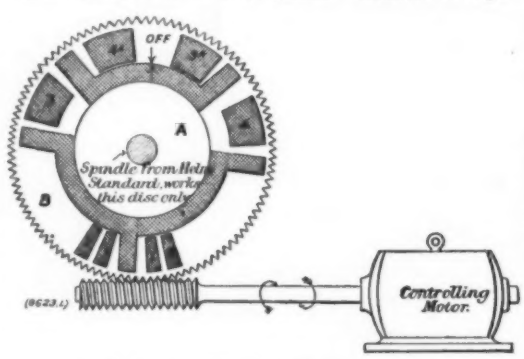
In surgical and obstetrical cases they give rise to grave complications, and in the alimentary tract of young children and debilitated adults they cause nausea, diarrhœa, and catarrh of the stomach and bowels. To infants they are often fatal. Cases of enteritis, or inflammation of the bowels, caused by the use of milk containing streptococci, have been reported by several observers.

Intestinal diseases caused by milk are not necessarily due to streptococci. A case of poisoning by milk from an inflamed udder is recorded. Prof. Rubner has shown that the toxines produced by milk bacteria may be as dangerous as the organisms themselves.

Milk is an excellent medium for the propagation of germs, especially of germs which are derived from the milk-giving animal and are, therefore, as it were, acclimated. This is particularly true when the udder is the seat of disease. It is now proved that most inflammations of the udder are caused by organisms, which also occasion disease when they reach the human alimentary canal, and medical records afford abundant evidence of the communication of such disease by milk. An epidemic of diarrhœa in a hospital was traced to the use of milk from a cow which had recently recovered from an inflammation of the udder. In this case two things are especially noteworthy. The cow had been cured, and the milk had been boiled. The udder, therefore, even after being healed, contained infectious matter which was not destroyed by boiling. Prof. Gaertner, in his manual of hygiene, says that such attacks of nausea and diarrhœa seldom occur when nearly or quite germ-free milk is used, and that the most effective treatment consists in the exclusion of milk from the dietary.

Other cases of illness, more insidious and less striking, may be traced to bovine tuberculosis.

Years ago the use of boiled instead of raw milk was adopted, chiefly as a preventive of tuberculosis. The question was regarded as settled when Koch, the discoverer of the tubercle bacillus, reopened it by denying at the tuberculosis congress held in London in 1901 the identity of human and bovine tuberculosis and the communicability of the disease from cattle to human beings, or conversely. Koch's assertion has, since then, been so thoroughly disproved by experiments on animals and the evidence of autopsies that Von Behring now goes so far as to say that every case of human tuberculosis is due to infection through milk in infancy, but that the disease may remain latent until the occurrence of conditions favorable to its development. Infection through



THE HUNTING SWITCH AND THE CONTROLLING MOTOR.

the lungs, to which Koch attributes the spread of tuberculosis, is regarded by Von Behring as merely a contributory cause. The truth may eventually be found to lie between these two extreme views.

As the communicability of bovine tuberculosis to human beings can no longer be doubted, the frequency of the occurrence of the disease in cattle becomes of interest. Klimmer found tubercle bacilli in 4 out of 25 samples of milk taken in Copenhagen, in 20 out of 117 in Berlin, in 3 out of 54 in Milan, in 4 out of 71 in St. Petersburg, in 12 out of 21 in Helsingfors, in 6 out of 30 in Paris and in 7 out of 100 in London. Dr. Rabinovich found virulent tubercle bacilli in 3 out of 8 specimens of the so-called "kindermilch," sold at high prices as especially suitable for infants.

The virulence of tuberculous milk is shown by an experiment made at the Berlin veterinary school, in which 0.00001 gramme (1/6000 grain) of milk from a diseased udder sufficed to infect a guinea pig. In general we may accept the statement of the English tuberculosis commission, that the majority of cases of human tuberculosis attributable to diet are caused by milk.

Tuberculosis is not the only bovine disease that is communicable to man. Others are cowpox, foot and mouth disease, splenic fever and, probably, rabies. In the German Empire, from 1887 to 1894, there were reported 600 cases of human infection with foot and mouth disease.

Milk may also contain vegetable and mineral poisons derived from the food and medicines given to the cow. Braungart has called attention to the great infant mortality in certain districts of Bavaria infested with poisonous plants, of which the crocus or meadow saffron appears to be the most dangerous. Hueppe attributes some cases of cholera infantum to milk from swill-fed cows. Hellebore and wild cherry, occurring in the fodder of cows, also make their milk unwholesome. Many poisonous medicines appear in the milk of cows to which they are given. Mercury, iodine, and arsenic are the most dangerous because of their virulence, and also because they do not affect the odor or taste of the milk.

Finally, there are the dangers due to the contamination of milk by the germs of various human diseases, and their rapid multiplication therein. This applies with especial force to typhoid. Prof. Jensen explains the frequent occurrence of typhoid bacilli in milk as follows: "Urine and fæces often contain vast numbers of bacilli. Petruschky found 170,000,000 in a cubic centimeter. Under these conditions every one acquainted with rustic habits will understand that no excessive lack of cleanliness is needed to account for contamination of milk or water." To infect milk it suffices to wash the milk pails in infected water. Other sources of contagion are the actual existence of the disease among the attendants and the horrible practice not uncommon in dairies, especially in cities, of using as litter the bedding of patients, either cured or dead. The occurrence of typhoid in cities provided with good water must be ascribed chiefly to milk. In Islington, England, 168 persons, living in 67 houses, died of typhoid due to infected milk, and a similar epidemic in St. Pancras claimed 431 victims.

The dissemination by milk of diphtheria and scarlet fever has also been proved repeatedly by the spread of these diseases among the customers of particular milk sellers, while the customers of others remained exempt.

Summing up the various dangers that lurk in milk we obtain the frightful result recently expressed by Prof. Escherich in these words: "Four-fifths of all the deaths of young infants are of such as have been artificially nourished, and are caused by disturbances of digestion due to the improper character and preparation of cow's milk."

Here are some statistics:

Mortality among children less than one year old, Berlin, 1885:

Food.	Death rate per 1,000.
Mothers' milk	7.6
Nurses' milk	7.4
Human and animal milk	23.6
Animal milk alone	45.6
Animal milk and milk substitutes	74.8

Relative mortality due to digestive disorders:

Food.	Legitimate.	Illegitimate.
Human milk	1.3	1.0
Human and animal milk	7.9	23.7
Animal milk alone	18.7	29.9
Animal milk and milk substitutes	51.1	71.9

The demand for reform in the use and handling of milk is therefore amply justified. Milk is often bought in shops which deal also in potatoes, smoked fish, and petroleum, and carried home in open vessels, so that street dirt is added to the cow dung which it already contains. Then it is left standing in a warm room for hours while bacteria rapidly multiply in it. It should, on the contrary, be boiled at once, quickly, and then immediately put to cool in the ice-box or in a closed vessel under the open water tap. The most rational plan would be to keep the milk cool and boil it in small quantities as wanted for immediate use, for the reason that boiling destroys certain substances and organisms which protect milk from the microbes of putrefaction. A return to the use of raw milk might be advised if we could be sure of having pure milk from healthy cows, but as this is not the case we must continue to boil milk, and thus destroy at least a part of its injurious bacteria. I say a part, because the bacilli of diphtheria and many others thrive better in boiled than in raw milk, the bactericidal properties of which keep them in subjection.

The care needed in the treatment of milk appears from a publication of the Imperial Health Bureau of Berlin, which states that the poisonous "peptonizing" or Fluegge's bacteria occur even in sterilized milk. Indeed, sterilized milk is peculiarly prone to rapid decomposition. It is best to avoid commercial "sterilized milk" and to sterilize at home, immediately before each feeding.

What do our milk inspectors inspect? Milk, naturally, but it would perhaps be better to inspect cows. The examination is made in market or street, with chemical tests and the balance. But no balance can weigh bacteria, which are the chief source of danger. Not until the official control of milk shall begin in the dairy, and shall include bacteriological and veterinary examinations and the enforcement of scientific hygiene in the stall and the milk room, shall we be able to give our children milk with perfect confidence. That such control is not Utopian is proved by the fact that it is now exercised, in essential points, by private persons. Wholesale milk dealers have compelled the farmers who supply them to employ veterinaries and institute other reforms, and intelligent dairymen have followed the good example. There is no apparent reason why that which some have found practicable should not be made obligatory upon all.—Abstract of a paper read by Dr. Sobelsohn before the Scientific Club of Vienna.

BREATHING IN LIVING BEINGS.*

It has been said that the most striking facts connected with respiration are its universality and its continuity. In popular language "the breath is the life." Breathing is not only a sign of life, it is a condition of its existence. Permanent cessation of breathing is regarded as a sign of death. Link up with this the icy coldness of death and you have two significant facts.

Respiration and calorification are therefore intimately related; in fact, calorification is one form of expression of the results of respiratory activity.

The popular view of respiration is an inference from what is observed in man and animals. During life the rise and fall of the chest goes on rhythmically from

* Abstract of a discourse delivered at the Royal Institution of Great Britain by Dr. William Stirling.

the beginning to the end. The respiratory exchanges effected in the breathing organs—lungs or gills—constitute "external respiration." This, however, scarcely touches the main problem, viz., what is called "internal respiration," or tissue respiration—i.e., the actual breathing by the living cells and tissues which make up a complex organism.

We are told that man does not live by bread alone. We know he requires, in addition, solids, fluids, and air. Taking these to represent the three graces, then air is of all the graces best.

The higher animals have practically no reserve stores of air—unlike what happens with the storage of fats and proteids—and hence the necessity for mechanisms by which air is continually supplied to the living tissues, and also by which the waste product of combustion, viz., carbon dioxide, is got rid of. Closure of the wind-pipe, even for a few minutes, brings death with it from suffocation. The entrance of oxygen is prevented and the escape of carbon dioxide is arrested.

The process of breathing is common to all living beings—to plants and animals alike. It consists essentially in the consumption of oxygen by the tissues and the giving out of carbon dioxide. It is immaterial whether the animals or plants live in water or air, the principle is the same in both cases. Living active protoplasm demands a supply of oxygen.

All the world's a stage. The human body is at once a stage, and a tabernacle—a vast theater—and the myriads of diverse cells of which it is composed, the players.

The cells or players, as active living entities, not only require food, but they require energy. The respiratory exchanges in and by the living cells provide the energy for the organism. This breathing by the cells is called "internal respiration." In a complex organism, therefore, the respiratory exchanges represent the algebraic sum of the respiratory activity of the several tissues that make up the organism. The various tissues, however, breathe at very unequal rates.

In one of his charming "contes philosophiques," Voltaire describes the visit of a giant of Sirius to our planet. Before reaching his journey's end he would have to traverse an aerial medium, and on arriving would see before him a fluid medium in continual movement, and tracts of solid land. After investigation—or no doubt he would be told, even though he was not personally conducted, that the water surface of this, our globe, is two and a half times greater than the land surface—he would discover that there are animals that live in air, others in water, and again others on land. Our visitor would find out that the respirable media are two—water and air—and that there are 210 parts of free oxygen in a liter of air, while there are only 3 to 10 dissolved in a liter of water.

Had Voltaire's friend paid us another visit during the present century, we should be able to tell him that the water of the Thames above London contains 7.40 cubic centimeters of O per liter; at Woolwich only 0.25, the decrease being due to the pollution of the river. Putting it broadly, water contains only 3 to 10 parts per liter, while air contains 210. Water breathers under good conditions have twenty times less O than air-breathers. It is as if air-breathers on land had the percentage of O_2 reduced to 1.

He would also be told that carbon dioxide—CO_2—is also remarkably soluble in water, and readily combines with certain bases present in water; thus water forms an admirable medium into which an animal may discharge its effete and poisonous irrespirable CO_2.

He would also be told that our blood contains 60 volumes per cent of gases, and that there is more O and less CO_2 in arterial blood than in venous blood.

Perhaps the name of Sir H. Davy might be whispered to him, for he was one of the first to detect the presence of gases O and CO_2 in blood.

In story, one has heard of the "Quest of the Holy Grail." I have even listened with rapt attention to an entrancing lecture on the "Quest of the Ideal." For the cell, the quest is the "quest of oxygen," and it is not happy until it gets it.

We speak of a distinction between air-breathers and water-breathers. If, however, we push the matter to its ultimate issue, we find that all our tissues—and equally those of plants—live in a water medium—in us the fluid lymph which exudes from our capillary blood vessels, and in plants the sap. Thus we come upon what at first seems a paradox, but is not so; all our cells not only live in water, but they live in running water. They are bathed everywhere by the lymph which is the real nutrient fluid for our cells. Thus, in its final form, all respiration is actually aquatic. The process of internal respiration, besides other conditions, requires the presence of a certain amount of water. In fact, all vital phenomena require the presence of water.

The unity and identity of the process in animal and vegetable cells, as the theater of combustion, is the striking fact. The means by which the necessary oxygen is brought to the cells are as varied as the forms of animated organisms themselves. This function exists for the cells, and not the cells for the function.

If the mountain will not go to Mohammed, Mohammed must go to the mountain. There are, at least, two principles on which animal cells obtain oxygen.

The air or water containing air is carried to the cells. This is the principle adopted in the lower invertebrates, as in sponges, and with regard to certain air-breathers such as insects.

The other principle is this, that an intermediary carries the respiratory oxygen from some more or less central localized or diffuse surface to the cells. This intermediary is the blood—an internal medium of exchange. The fluid part of the blood may carry the oxygen supply and remove the carbonic dioxide waste. This is the case in many of the invertebrates, and it reaches its highest development in the vertebrates. Hence in them the circulating and respiratory systems reach their fullest development.

In most invertebrates the fluid part of the blood contains the nutritive substances and also the oxygen and carbonic acid. In the vertebrates, the hæmoglobin of the red blood corpuscles carries the oxygen from the gills or lungs to the tissues, while the CO_2 is contained in and carried chiefly by the blood plasma from the tissues to the gills or lungs.

It is singular that in the cephalopods, such as the squid and cuttle-fish, the blood is bluish in tint; and this is due to the presence in the plasma of a respiratory pigment called hæmocyanin. This body has a composition like that of hæmoglobin, but copper is substituted for the iron of the hæmoglobin. Copper also exists in organic combination in the red part of the feathers of the plantain-eater or turaco.

The real aristocracy with genuine blue blood are the crabs, lobsters, squids, and cuttle-fishes.

Perhaps one of the most striking ways of dissociating this accessory mechanism from the activity of the cell itself is by the use of a poison. When a person is poisoned by coal gas, what happens? The coal gas contains carbon monoxide. This gas does not poison invertebrate animals or plants. Still it kills vertebrate animals. Why? It does not kill by acting on the living cells, only by depriving them of oxygen and asphyxiating them. It combines with the respiratory pigment hæmoglobin. Chloroform, ether, and similar drugs destroy the actual life of the cell elements by destroying their irritability.

In 1771, Priestley found that air vitiated by combustion of a candle, or by the breathing of animals—such as mice—could be made pure or respirable again by the action of green plants.

Under certain conditions, however, Priestley found that plants gave off carbonic acid, and the air did not support combustion or animal life. He regarded these as "bad experiments," and he selected what he was pleased to regard as "good experiments," i.e., those in which the air, rendered impure by the respiration of animals, was rendered respirable by the action of green plants.

In 1779 John Ingen-Housz published his "Experiments on Vegetables, discovering their great power of purifying the common air in sunshine, and of injuring it in the shade and at night."

He confirmed Priestley's observations that green plants thrive in putrid air, and that vegetables could convert air fouled by burning of a candle, and restore it again to its former purity and fitness for supporting flame, and for the respiration of animals—or, as he puts it, "plants correct bad air."

In 1787 Ingen-Housz, an English physician at the Austrian court, found that only in daylight did green plants give off oxygen. In darkness, or where there was little light, they behaved like animals so far as exchange of gases is concerned, i.e., they used up oxygen and exhaled carbonic acid. He found also that all roots, when left out of the ground, yielded by day and by night foul air, i.e., carbonic acid.

In the same year, 1804—the year of Priestley's death—Nicolas Theodore de Saussure, a Swiss naturalist and chemist, published his "Recherches Chimiques sur la Végétation (Paris, 1804), a veritable encyclopedia of experiments of the effects of air on flowers, fruits, plants, and vegetation generally, and on the effects of these on atmospheric acid.

It is an old adage—the exception proves the rule. The exception "probes" the rule as the surgeon's probe probes a wound. The *tactus eruditus* of the surgeon, by his probe—indeed an elongated tactile sense—enables him to discover the presence or absence of a body in a wound. Had Priestley used the probe of a bad experiment, he in all probability would have anticipated the discovery of Ingen-Housz.

How do the vast number of plants, the microbes, the bacteria without chlorophyl, get oxygen? Most of them get it as we get it. Some, however, cannot live in pure oxygen and are anærobic, such as the microorganisms that cause tetanus, malignant œdema, and those that set up butyric acid fermentation.

Pushing the matter still further, it is extremely probable that the oxidation processes in our tissues are largely due to the presence of oxydases.

This raises the question as to the part played by the nucleus of a cell in its respiratory processes.

Is the source of muscular energy to be sought in oxidation or cleavage processes in tissues? In some animals there is not a direct relation between the muscular work and oxygen consumed, though there is to heat production. Bunge, on this ground, thought that the intestinal parasites of warm-blooded animals must have their oxygen at a minimum. In the intestinal contents there is no estimable oxygen; there active reduction processes go on. Entozoa might get oxygen from O_2 diffusing from blood vessels.

Bunge found that intestinal worms of the cat and pike can live in an alkaline solution of common salt, free from gases, under Hg, for four to six days. They made active movements, and gave off much CO_2.

Ascaris lumbricoides from the intestine of the pig lived four to six days in 1 per cent boiled NaCl solution. It made little difference whether oxygen or hydrogen was passed through the fluid. They lived seven to nine days if fluid was saturated with carbon dioxide, so that they have accommodated themselves to high percentages of carbon dioxide.

They give off to the fluid valerianic acid, an acid with a characteristic butyric acid odor. These worms contain a very large quantity of glycogen, the dry body yielding 20 per cent to 34 per cent of this carbohydrate.

One hundred grammes Ascaris, placed in boiled normal saline solution, used per day—

0.7 gramme glycogen,
0.1 gramme sugar,
No fat;

and yielded—

0.4 gramme CO_2
0.3 valerianic acid.

It would seem that glycogen had split into CO_2, and valerianic acid—

$$4C_6H_{12}O_6 = 9CO_2 + 3C_5H_{10}O_2 + 9H_2$$
$$720 = 396 + 306 + 18$$

Is it a genuine fermentation?

Weinland found that he could express by Buchner's method a substance "zymase," which could split glycogen into CO_2 and valerianic acid.

Turning now to respiration in invertebrate animals, and dealing first with those which live in water, let us see some of the contrivances by which this end is achieved. The mechanisms are but means to an end. The ultimate union of oxygen, and the discharge of carbon dioxide with the liberation of energy, occur in the protoplasm of the cell itself.

There are two distinct processes, and it may be that the oxygen is introduced by one portal and the carbon dioxide got rid of by another, or it may be that one portal may do for both processes—the letting in of oxygen and the giving off of carbon dioxide.

Although the principle itself is simple, the variety of mechanisms adopted by nature to secure this double function is remarkable. Let us glance at some of the mechanisms proceeding from the simple to the complex, and first with regard to those animals that live in water.

Consider the oceanic fauna. It is immense both from the point of view of number and variety. Save insects and certain groups of mollusks, all invertebrates are aquatic. Among vertebrates, fishes have aquatic respiration, and some mammals, e.g., cetaceans or whales, have water as their sphere of existence, though they depend on the air for their respiratory oxygen.

The evolution from an aquatic to an aerial mode of existence can be traced in the animal kingdom, and may even be seen within limits in the history of certain species.

Every living cell, animal or vegetable, requires for its continued existence a supply of oxygen, and every living cell exhales carbon dioxide. The exchange of these two gases between the fluids of the body and the outer medium is the process of respiration. The simplest form of respiratory exchange occurs where there is no specially differentiated organ or mechanism for this purpose, so-called diffuse respiration. The whole surface of the organism in a watery medium may be concerned in this respiratory exchange. This is only possible, however, so long as the boundary surface, skin, or otherwise is permeable to gases, and no great respiratory exchanges are necessary.

In some animals, the respiratory mechanism is closely related to the motor apparatus, as in some crustacea. In some mollusca the nutritive and respiratory mechanisms are closely related. In the highest of all there is central apparatus—gills or lungs—for the respiratory exchange between the blood and the air, and a circulatory apparatus for carrying the blood to and from the respiratory organs. The adaptivity of insects to varied conditions of oxygen supply is marvelous.

Before showing some classical experiments and illustrating the principles already laid down, I should like again to direct your attention to the association of several processes with respiratory mechanisms.

[The lecture was illustrated by means of lantern slides, showing the respiratory mechanisms from the lowest to the highest animals, and also by a number of experiments dealing with the chemical exchanges in the process of respiration. Lastly, the classical experiment of John Hunter, on the pneumaticity of the bones of birds, was shown in the duck. A candle flame was extinguished when held in front of the divided trachea, when air was blown into the divided humerus bone of the wing.]

CONTEMPORARY ELECTRICAL SCIENCE.*

THE SINGING ARC.—A. Blondel describes the conditions under which an arc between the same carbons may be made either into a hissing arc, a singing arc, or a silent arc, without altering the voltage from its ordinary value of 120. A hissing or screaming arc is obtained when the arc is short for the voltage employed, say 1 millimeter, and especially when an inductance is inserted in the circuit. On removing the inductance and lengthening the arc to 3 or 4 millimeters, it emits a musical note. The screaming arc is intermittent, and is due to the proximity of the current to the point of instability. The tension-and-current curve descends at first, and then slowly rises. Thus there is a tendency for the tension to increase and extinguish the arc until it is relighted on the cooling of the carbons. Longer arcs have a greater current intensity, a smaller tension and a much smaller variation of ten-

* Compiled by E. E. Fournier d'Albe in the Electrician.

sion. They never approach the critical tension, and are, therefore, not extinguished. When the current is so strong that the rising branch of the curve is reached there is no tendency toward oscillation, and the arc becomes silent. The current then increases with the tension, as in ordinary conductors.—A. Blondel, Comptes Rendus, June 26, 1905.

Electric Arc in a Vacuum.—C. D. Child has continued his researches on the arc in a tube exhausted by means of a mercury pump. Working with graphite terminals, he found that the average drop of potential was nearly the same as in the case of carbon terminals, but at pressures below 1 millimeter the anode drop becomes much smaller, so that it is less than that at the cathode. Thus, at 0.3 millimeter pressure the anode drop diminishes from 25 to 7 volts, whereas the cathode drop only falls from 15 to 13.5 volts. The author noticed that occasionally a glow would appear on some part of the anode, and whenever this appeared the anode drop of potential would rise from 5 volts to 15 or 20. The anode glow and the anode drop are, in fact, parts of the same phenomenon. These phenomena could be markedly increased by placing a piece of platinum foil somewhere across the arc. When the foil was perforated and placed near the anode, a bright streak of light would pass through the hole toward the cathode, showing that the anode glow was caused by particles issuing from the anode. When a metal anode was put instead of the graphite, no essential difference was noticed. The author found that metals with low melting points could be used as cathodes by inserting them in an iron cup.—C. D. Child, Physical Review, June, 1905.

JAPANESE HERALDRY.*

Everything connected with Daï Nippon, or Japan, has a heightened interest for us at present through the war in Manchuria. The branch of graphic art herein described has, to be sure, very little connection with modern Japanese military affairs, yet was intimately entwined with the ancient military order down to the end of the first half of the nineteenth century.

The Japanese coats-of-arms, in spite of striking differences, have many points of resemblance to European armorial bearings. The European armorial device is usually displayed upon the background of a shield, which is totally lacking in the Japanese coat-of-arms, or mon. This difference is due to the fact that the shield had no especial prominence in Japan, while with us it had a very marked significance in military equipment. A second noticeable characteristic of Japanese heraldry is the subordinate part which the tinctures play, while European blazonry is highly dependent upon the tinctures and could hardly exist without them. The mon, however, when displayed upon flags, banners, or other articles serving a similar purpose, was given certain fixed colors, to make it distinct and recognizable from a distance. Thus, for example, the old daïmyo or princely family of Satake of Oshiu-Akita displays a black flag with a white fan, or ogi, in the middle, on which is placed a black circle (Fig. 1); the daïmyo family Matsudaira of Ise-Kuwana has, upon a blue field, a small white circle surrounded by five larger ones (Fig. 2); the daïmyo family Ikeda of Bizen-Okayama shows a white butterfly flying upon a yellow field, etc.

In other cases, the mon commonly appears as a flat, unshaded, light figure on a dark ground, or, vice versa, as a silhouette on a light field. This manner of representation calls for a very simple, distinctly outlined form, like the well-designed heraldic devices which have come down to us from the thirteenth and fourteenth centuries.

While European coats-of-arms were native to the banner and the shield, the Japanese armorial bearings apparently owed their origin to the designing of fabrics. Just as the word "arms" was anciently used for both weapons and bearings—we still speak of "one who is entitled to bear arms"—so the word "mon" means design or figure (jimon—figure on a fabric), surely an indication of its origin. The early preference of a family for some particular design which it caused to be figured upon the materials for clothing, hangings, etc., may gradually have developed the distinctive figure into a hereditary emblem. The great love for nature displayed by the Japanese people of high and low degree—a sympathetic sensitiveness possessed by only a few in the Occident—makes this conjecture in regard to the origin of their family emblems not so improbable. Of course, this hypothesis is not maintained of all existing mons; but many of them have arisen thus.

The motifs of the Japanese heraldic designs, which by their simplicity recall our commercial trade-marks, given colors not being essential, are mainly taken from the vegetable world, from birds, amphibia and insects, from military trappings, household gear, or

Fig. 1.
White fan on black field.

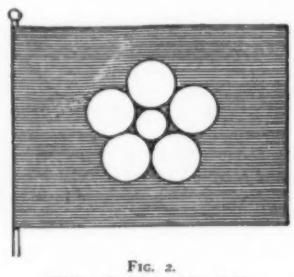


Fig. 2.
White circles on blue field.

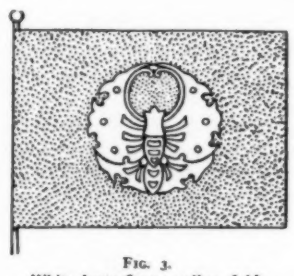


Fig. 3.
White butterfly on yellow field.

Fig. 4.
Bamboo and Sparrows.

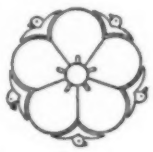


Fig. 5.
Plum blossom and little wild geese.

Fig. 6.
Melon blossom and butterfly.

Fig. 7.
Fan and falcon feathers.

Fig. 8.
Falcon feathers in ring.

Fig. 9.
Variant of Fig. 8.

Fig. 10.
Second variant of Fig. 8.

Fig. 11.
Three fans.

Fig. 12.
Three notched fans.

Fig. 13.
Europeanized mon.

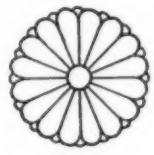


Fig. 14.
Imperial chrysanthemum.

Fig. 15.
Paulownia imperialis.

Fig. 16.
Mallow leaves (mon of shoguns).

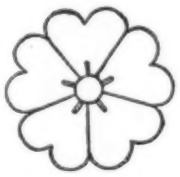


Fig. 17.
Cherry blossom.

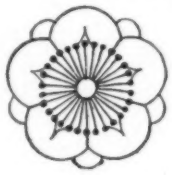


Fig. 18.
Double plum blossom.

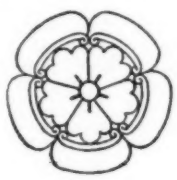


Fig. 19.
Melon blossom.

Fig. 20.
Wheel of three gentians.

Fig. 21.
Upright water plantain within circle.

Fig. 22.
Drooping glycinia.

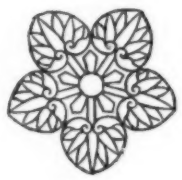


Fig. 23.
Five mallow leaves.

Fig. 24.
Hare.

Fig. 25.
Antlers bent toward each other.

Fig. 26.
Two cranes.

Fig. 27.
Flight of three wild geese.

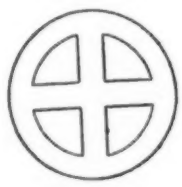


Fig. 28.
Ring of a bridle bit.

Fig. 29.
Crossed axes within a ring.

Fig. 30.
Wheel of six axes.

* Prof. Ströhl in the Deutscher Buch- und Steindrucker. Translated by M. E. Chapin for Inland Printer.

from geometrical figures. Large animals are seldom represented, human figures never. Ancient Chinese script characters (kakuji) are sometimes used as mons, their graphic form, not unlike geometric ornament, making this use not inappropriate (Fig. 40). These various heraldic motifs are used singly, or more frequently combined, on fields without definite boundaries, or bounded by circles (kokumochi, Fig. 21), rings (maru, Fig. 29), quadrangles (kaku, Fig. 40), hexagons (kikko), etc. Then, too, motifs of different characters are sometimes combined, as, for example, bamboo and sparrows (Fig. 4), plum blossoms and little wild geese (Fig. 5), melon blossom and butterfly (Fig. 6), fan and falcon feather (Fig. 7), etc. The illustrations show various kinds of these mons, and prove that the Japanese heraldic artist knows how to make different mons from the same motifs. (Figs. 29-31.) Such variations of a single motif are used to designate different branches of one family. Thus, for example, the ex-daïmyo Viscount Abe Masanori of Kadzusa-Saga bears two diagonally crossed falcon feathers surrounded by a ring, the upper feather "bent," in heraldic parlance, to the left (Fig. 8); ex-daïmyo Count Abe Masatake of Bingo-Matsuyama displays the same outlines, but with the feathers dotted and the upper feather turned to the right (Fig. 9); while ex-daïmyo Viscount Abe Masakoto of Bushiru-Okabe shows the same feathers as those of Abe Masanori's bearings, but feathers and circular background dark with light outlines (Fig. 10). Ex-daïmyo Viscount Okotchi Masatada of Kadzusa-Odaki carries a device composed of three fans with smooth edges arranged inside one circle (Fig. 11), while ex-daïmyo Viscount Okotchi Kiko of Kodzuke-Takasaki uses as a mon three similar fans with notched edges (Fig. 12), the device being known as the Taka-saki-ogi. Space is lacking to illustrate fully these variations of the mon, though of course very interesting to the student of heraldry.

The Japanese decorates everything, as has been said, with his heraldic emblem; clothing, harness, household utensils, lamps, fans, medals and other products of art and industry. The simplicity of the forms permits of such an intensive use of the mon, which is princes of the imperial house bear, since 1871, a fourteen-petaled kiku-mon seen in reversed view.

The use of the imperial coats-of-arms is forbidden to all but members of the imperial family, and in 1868, 1871, 1880 and 1900 ordinances appeared which warned strictly against the use of the imperial mon on vases, tickets, buildings, etc.

The coat-of-arms of the former shoguns or imperial marshals of the house of Minamoto Tokugawa, which ruled the land from 1603 until the downfall of the last shogun, Hitotsubachi Yoshi Nobu or Keiki, in 1867, shows three mallow leaves placed with points converging inside of a ring (Aoi go mon, Fig. 16). In the sixties this device was supposed by Europeans to be the imperial coat-of-arms, on account of the error, encouraged by the crafty Japanese, through which the shogun was confused with the Mikado by foreigners.

These examples of Japanese heraldry offer no exhaustive view of the subject, but serve to give some insight into the character of the national style in this branch of graphic art.

FIG. 31.
Four axes.

FIG. 32.
Uright anchor.

FIG. 33.
Vase within a ring.

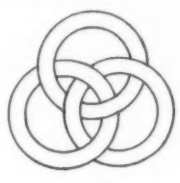


FIG. 34.
Three interlaced rings.

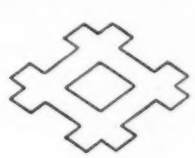


FIG. 35.
Well curb.

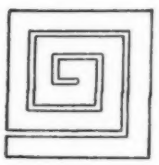


FIG. 36.
Lightning.

FIG. 37.
Triple tomoe, or wave symbol.

FIG. 38.
Cluster of triple tomoe.

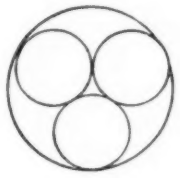


FIG. 39.
Three circles in circle.

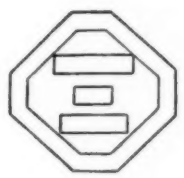


FIG. 40.
Chinese figure 3.

by preference turned to account as the unit for repetition in the decoration of fabrics and paper. Foreigners, unfamiliar with Japanese heraldry, are rarely able to recognize the hereditary and emblematic elements in Japanese decorative design.

To-day, when the educated Japanese feels obliged to adopt, along with the good and bad features of European culture, the ugly European costume, in place of the kimono and haori, the mon is gradually disappearing from decorative surfaces. This preference for European manners and lack of manners has here and there brought about the attempt to remodel the ancient native heraldry, to cram the figures into escutcheons, to provide these with supporters, etc. (See the overburdened coat-of-arms of a gentleman of the well-known race of the Aoki, Fig. 13.) Fortunately, the attempt has generally been abortive.

Of much interest, especially now, is the coat-of-arms of the Emperor Mutsu Hito, the one-hundred-and-twenty-first Mikado of his dynasty, which has reigned over the "land of the rising sun" since 660 B. C., or for 2,564 years. The imperial coat-of-arms, kiku-no-hana-mon, based upon a crysanthemum blossom, shows a flower of sixteen petals joined at the tips by little curves (Fig. 14). This kiku-mon usually appears in gold on a white or red ground. In ancient times, this flower, in eight-petaled form, is said to have been worn by those emperors who renounced the throne and withdrew from the world. Powers of prolonging life were ascribed to the chrysanthemum.

Besides the kiku-mon, the Mikado makes use of a second coat-of-arms, the kiri-mon, leaves and blossoms of the paulownia imperialis. It shows three leaves upon which arise three spikes of flowers, the center spike bearing seven, and the two lateral spikes five blossoms each (Fig. 15). This mon, which is commonly displayed in violet on white, or reversed, is said to owe its origin to the adornment of the imperial robes.

Japan has no national coat-of-arms, but the kiku-mon may be looked upon in that light, since it is used by the Japanese government as European national coats-of-arms are used by the respective European governments. (Compare also Japanese postage-stamps.) The

SEALS FOR FREIGHT CARS.

A LONG freight train rumbled into the exchange yard at Rotterdam Junction a few minutes after 9 o'clock the other evening, and, after groaning and grinding and swaying its passage over the multiplicity of frogs, came to a standstill, says the Boston Herald. Boston was the destination of many of the cars, and after the incoming locomotive had been sent away to the roundhouse a switcher backed up and began the work of selecting all cars that were to be forwarded to eastern points on the system. These were attached to others standing in the yard, and after the lapse of an hour a completed train was made up.

Before it started on its journey the conductor in charge walked its entire length, going down on one side and coming back on the other. He stopped before the doors of each car and, lifting his lantern to a small loop of tin, and in some cases of wire, carefully scrutinized a small disk of lead, which movement was followed by making an entry in a book. He then made an entry of the number of each car and added its destination, the road to which it belonged and other data that could be used for the purpose of identification.

But of all the information contained in the conductor's little blank book that first recorded was perhaps the most important, as it related to the condition of the seals attached to the doors. If they were intact it was quite evident that during the run from Buffalo there had been no tampering with the merchandise with which the cars were loaded.

There was one car in the lot whose contents had originated at a small station away out on another system. When the freight was delivered to the railroad the receiving clerk or agent gave to the driver of the truck a slip of paper which was a receipt for the articles received. This was given to the shipper and placed on file. After the car into which the freight was loaded had received its maximum amount the agent placed inside the clasp on the door a thin, tapelike piece of tin with a small dab of lead at one end. Underneath was a tongue of the same metal which fitted into an eyelet at the other end of the strip of tin. After the ends had been brought together they were placed in the jaws of a powerful seal press, which pinched the lead into little disks on each side.

An examination would have shown that a raised number had been added to the center of each of the metal patches. If this proceeding had taken place at the station beyond, a number differing from the one under consideration would have appeared, and so the changes would have continued until the end of the line was reached. It may not be generally known that every freight receiving station in the United States has a numerical designation, but such is the fact.

At the time the agent finished his work upon the seal the car was standing upon a side track. When a freight train pulled up the conductor examined the seals upon the lone car and satisfied himself that they had been properly adjusted, after which it was switched into the train and began its journey eastward.

About 200 miles from the starting point the conductor reached the end of his run and the train was taken in charge by another. His first duty was to make a record of the condition of all the seals and their numbers. When he reached the car that had been loaded for Boston he found that the seal had been broken. A special entry was made of this fact, and it was also called to the attention of the yard clerk if the place was of sufficient importance to warrant the employment of such an official; if not, then the agent was found and a new seal substituted for the old one, the number showing where it had been put on.

The conductor who had been relieved of duty sent his record to the officer in charge of transportation, or it may have gone to the superintendent of car service, there being no universal custom, and it was put away to be referred to in case the evidence it contained was ever required in defending the company in a claim for damages.

The plan described was carried out at every point where there was an exchange of cars, or where a new conductor took charge of the train. Finally the Boston car reached its destination, the consignee was notified, and he sent his wagons to bring its contents to his place of business.

The freight appeared to be cantaloupes, and in checking off it was found that there was one case less than the bill of lading called for. The matter was brought to the attention of the shipper, and he took it up with the initial line that makes the collections, and the one to which the consignor looks for indemnification in case a loss in transit is reported. The agent at the shipping point referred the case to the traffic manager, and reference to the conductors' reports on the day the shipment was made showed that a new seal had been attached while the car was on the property of the company.

It was quite evident that the theft had occurred somewhere between the initial point and where the second conductor took charge, and as the papers appeared to be straight and the shipper an old customer of the road there was no hesitancy on the part of the officials to make the loss good. The shipper thereupon gave the necessary credit to the consignee, and the incident came to an end, except that the railroad company placed the case in the hands of its detective force to locate, if possible, the purloiner of the melons.

But suppose the entire record of the train showed that the seal had been undisturbed, what course would have then been pursued? Simply this: All of the roads in interest would have agreed to the payment of a line claim—that is, each road would have paid back to the shipper a sum based upon its proportion of the through rate. It often requires a month or more to reach a final settlement of a claim of this character, as it is necessary for each road to hunt up all the records relating to the shipment on which reimbursement is asked, and it frequently occurs that a dispute on responsibility will be interjected. It will be seen that, in the case of the melon shipment, the claim was speedily settled because of the evidence given by the detached little piece of tin. The value of the seal is, therefore, established.

The history of the adoption of the car seal in the United States is not clear, but it is known that in the early days of railroading it was hardly necessary, as there was very little exchanging of equipment between connecting lines. This was due in considerable part to the fact that a uniform gage had not been observed in the construction of roadbeds. The Erie, for instance, had a six-foot gage, while the lines with which it interchanged had 4.8½, the standard of to-day. This, however, did not prevent an exchange of cars, as it was the custom to make a change of trucks to save a transfer of the contents of a car. It can readily be seen that this was a slow and tedious process, and to attempt a thing of the kind to-day would very nearly paralyze the entire transportation business of the country.

It was the custom on the Erie at this early day to lock the doors of its freight cars, but not for the purpose of identification, the practice being primarily to save the company from the depredations of thieves. In place of the present seal substantial brass padlocks were used to secure the door clasps, and a conductor when given a train was supplied with a key by the company, for which he made a deposit of $5. This drew interest at the rate of 6 per cent, and the records of the company show several instances where old conductors when leaving the road had had returned to them a sum greatly in excess of the original deposit.

It is not known how many car seals are used per year throughout the United States, but the number runs up into the millions, the cost being a considerable expense to the freight departments.

[Continued from SUPPLEMENT No. 1552, page 24875.]

DIAMONDS.*

By SIR WILLIAM CROOKES.

GRAPHITE.

INTERMEDIATE between soft carbon and diamond come the graphites. The name graphite is given to a variety of carbon, generally crystalline, which in an oxidizing mixture of chlorate of potassium and nitric acid forms graphitic oxide. This varies in color from green to brown or yellow, or it is almost without color, according to the completeness of the reaction. Graphites are of varying densities, from 2 to 3, and generally of crystalline aspect. Graphite and diamond pass insensibly into one another. Hard graphite and soft diamond are near the same specific gravity. The difference appears to be one of pressure at the time of formation.

Some forms of graphite exhibit the remarkable property by which it is possible to ascertain approximately the temperature at which they were formed, or to which they have subsequently been exposed. Sprouting graphite is a form, frequently met with in nature, which on moderate heating swells up to a bulky, very light mass of amorphous carbon. Moissan has found it in blue ground from Kimberley; my own results verify his. When obtained by simple elevation of temperature in the arc or the electric furnace graphites do not sprout; but when they are formed by dissolving carbon in a metal at a high temperature and then allowing the graphite to separate out on cooling, the sprouting variety appears. The phenomenon of sprouting is easily shown. I place a few grains in a test-tube and heat it to about 170 deg. C., when you see the grains increase enormously in bulk and fill the tube with a light form of amorphous carbon.

The resistance of a graphite to oxidizing agents is greater the higher the temperature to which it has previously been exposed. Graphites which are easily attacked by a mixture of fuming nitric acid and potassium chlorate are rendered more resistant by strong heat in the electric furnace.

BOILING AND MELTING POINT OF CARBON.

On the average the critical point of a substance is 1.5 times its absolute boiling point. Therefore the critical point of carbon should be about 5,800 deg. Ab. But the absolute critical temperature divided by the critical pressure is for all the elements so far examined never less than 2.5; this being about the value Sir James Dewar finds for hydrogen. So that, accepting this, we get the maximum critical pressure as follows, viz., 2,320 atmospheres:

$$\frac{5{,}800^\circ \text{ Ab.}}{\text{CrP}} = 2.5, \text{ or } \text{CrP} = \frac{5{,}800^\circ \text{ Ab.}}{2.5}, \text{ or 2,320 atmospheres.}$$

Carbon and arsenic are the only two elements that have a melting point above the boiling point; and among compounds carbonic acid and fluoride of silicium are the only other bodies with similar properties. Now, the melting point of arsenic is about 1.2 times its absolute boiling point. With carbonic acid and fluoride of silicium the melting points are about 1.1 times their boiling points. Applying the ratios to carbon we find that its melting point would be about 4,400 deg.

Therefore, assuming the following data,

Boiling point	3,870 deg. Ab.
Melting point	4,400
Critical temperature	5,800
Critical pressure	2,320 Ats.

the Rankine or Van der Waals formula calculated from the boiling-point and critical data would be as follows:

$$\log. P = 10.11 - 39{,}120/T,$$

and this gives for a temperature of 4,400 deg. Ab. a pressure of 16.6 Ats. as the melting-point pressure. The results of the formula are given in the form of a table:

Temperature. Ab.	Pressure. Ats.	
3,870 deg.	1.00	Boiling point.
4,000	2.14	
4,200	6.25	
4,400	16.6	Melting point.
4,600	40.4	
4,800	91.2	
5,000	193	
5,200	386	
5,400	735	
5,600	1,330	
5,800	2,320	Critical point (15 tons per square inch.)

If, then, we may reason from these rough estimates, above a temperature of 5,800 deg. Ab. no amount of pressure will cause carbon vapor to assume liquid form, while at 4,400 deg. Ab. a pressure of above 17 atmospheres would suffice to liquefy some of it. Between these extremes the curve of vapor pressure is assumed to be logarithmic. The constant 39,120 which occurs in the logarithmic formula enables us to calculate the latent heat of evaporation. If we assume the vapor density to be normal, or the molecule in vapor as C_2, then the heat of volatilization of 12 grammes of carbon would be 90,000 calories; or, if the vapor is a condensed molecule like C_6, then the 12 grammes would need 30,000 calories. In the latter case the evaporation of 1 gramme of carbon would require 2,500 calories, whereas a substance like zinc needs only about 400 calories.

A NEW FORMATION OF DIAMOND.

I have long speculated as to the possibility of obtaining artificially such pressures and temperatures as would fulfill the above conditions. In their researches on the gases from fired gunpowder and cordite, Sir Frederick Abel and Sir Andrew Noble obtained in closed steel cylinders pressures as great as 95 tons to the square inch, and temperatures as high as 4,000 deg. C. According to a paper recently communicated to the Royal Society, Sir Andrew Noble, exploding cordite in closed vessels, has obtained a pressure of 8,000 atmospheres, or 50 tons per square inch, with a temperature reaching in all probability 5,400 deg. Ab.

Here, then, we have conditions favorable for the liquefaction of carbon, and were the time of explosion sufficient to allow the reactions to take place, we should certainly expect to get the liquid carbon to solidify in the crystalline state.*

By the kindness of Sir Andrew Noble I have been enabled to work upon some of the residues obtained in closed vessels after explosions, and I have submitted them to the same treatment that the granulated iron had gone through. After weeks of patient toil I removed the amorphous carbon, the graphite, the silica,† and other constituents of the ash of cordite, and obtained a residue among which, under the microscope, crystalline particles could be distinguished. Some of these particles, from their crystalline appearance and double refraction, were silicon carbide; others were probably diamonds. The whole residue was dried and fused at a good red heat in an excess of potassium bifluoride, to which was added during fusion 5 per cent of niter. (Previous experiments had shown me that this mixture readily attacked and dissolved silicon carbide; unfortunately it also attacks diamond to a slight degree.) The residue, after thorough washing and then heating in fuming sulphuric acid, was washed, dried, and the largest crystalline particles picked out and mounted. All the operations of washing and acid treatment were performed in a large platinum crucible by decantation (except the preliminary attack with nitric acid and potassium chlorate, when a hard glass vessel was used); the final result was washed into a shallow watch-glass and the selection made under the microscope.

I project on the screen a few photographs of these crystals. From the treatment they have undergone, chemists will agree with me that diamonds only could stand such an ordeal; on submitting them to skilled crystallographic authorities my opinion is confirmed. Speaking of the one before you (303), Prof. Bonney calls it "a diamond showing octahedral planes with dark boundaries due to high refracting index." After careful examination, Prof. Miers writes of the same crystal diamond: "I think one may safely say that the position and angles of its faces, *and of its cleavages*, the absence of birefringence, and the high refractive index, are all compatible with the properties of the diamond crystallizing in the form of an octahedron. Others of the remaining crystals, which show a similar high refractive index, appeared to me to present the same features."

It would have been more conclusive had I been able to get further evidence as to the density and hardness of the crystals; but I am still working at the subject, and hope to add these confirmatory tests. From what I have already said, I think there is no doubt that in these closed vessel explosions we have another method of producing the diamond artificially.

Sensational as is the story of the diamond industry in South Africa, quite another aspect fixes the attention of the chemist. The diamonds come out of the mines, but how did they get in? How were they formed? What is their origin?

Gardner Williams, who knows more about diamonds than any man living, is little inclined to indulge in speculation. In his fascinating book‡ he frankly says:

"I have been frequently asked, 'What is your theory of the orginal crystallization of the diamond?' and the answer has always been, 'I have none; for after seventeen years of thoughtful study, coupled with practical research, I find that it is easier to "drive a coach and four" through most theories that have been propounded than to suggest one which would be based on any non-assailable data.' All that can be said is that in some unknown manner carbon, which existed deep down in the internal regions of the earth, was changed from its black and uninviting appearance to the most beautiful gem which ever saw the light of day."

METEORIC DIAMONDS.

Another diamond theory appeals to the fancy. It is said the diamond is a gift from Heaven, conveyed to earth in meteoric showers. The suggestion, I believe, was first broached by A. Meydenbauer,§ who says: "The diamond can only be of cosmic origin, having fallen as a meteorite at later periods of the earth's formation. The available localities of the diamond contain the residues of not very compact meteoric masses which may, perhaps, have fallen in prehistoric ages, and which have penetrated more or less deeply, according to the more or less resistant character of the surface where they fell. Their remains are crumbling away on exposure to the air and sun, and the rain has long ago washed away all prominent masses. The inclosed diamonds have remained scattered in the river beds, while the fine light matrix has been swept away."

According to this hypothesis, the so-called volcanic pipes are simply holes bored in the solid earth by the impact of monstrous meteors—the larger masses boring the holes, while the smaller masses, disintegrating in their fall, distributed diamonds broadcast. Bizarre as such a theory appears, I am bound to say there are many circumstances which show that the notion of the heavens raining diamonds is not impossible.

The most striking confirmation of the meteoric theory comes from Arizona. Here, on a broad open plain, over an area about five miles in diameter, have been scattered one or two thousand masses of metallic iron, the fragments varying in weight from half a ton to a fraction of an ounce. There is little doubt these masses formed part of a meteoric shower, although no record exists as to when the fall took place. Curiously enough, near the center, where most of the meteorites have been found, is a crater with raised edges three-quarters of a mile in diameter and about 600 feet deep, bearing exactly the appearance which would be produced had a mighty mass of iron struck the ground and buried itself deep under the surface. Altogether ten tons of this iron have been collected, and specimens of the Canyon Diablo meteorite are in most collectors' cabinets.

An ardent mineralogist—the late Dr. Foote—cutting a section of this meteorite, found the tools were injured by something vastly harder than metallic iron. He examined the specimen chemically, and soon after announced to the scientific world that the Canyon Diablo meteorite contained black and transparent diamonds. This startling discovery was afterward verified by Profs. Moissan and Friedel, and Moissan, working on 183 kilogrammes of the Canyon Diablo meteorite, has recently found smooth black diamonds and transparent diamonds in the form of octahedra with rounded edges, together with green hexagonal crystals of carbon silicide. The presence of carbon silicide in the meteorite shows that it must, at some time, have experienced the temperature of the electric furnace. Since this revelation, the search for diamonds in meteorites has occupied the attention of chemists all over the world.

I am enabled to show you photographs of true diamonds I myself have extracted from the Canyon Diablo meteorite. A fine slab of the meteorite, weighing about seven pounds, is on the table before you.

Here, then, we have incontestable proof of the truth of the meteoric theory. Under atmospheric influences the iron would rapidly oxidize and rust away, coloring the adjacent soil with red oxide of iron. The meteoric diamonds would be unaffected, and left on the surface of the soil, to be found haphazard when oxidation had removed the last proof of their celestial origin. That there are still lumps of iron left at Arizona is merely due to the extreme dryness of the climate and the comparatively short time that the iron has been on our planet. We are here witnesses to the course of an event which may have happened in geologic times anywhere on the earth's surface.

Although in Arizona diamonds have fallen from the skies, confounding our senses, this descent of precious stones is what may be called a freak of Nature rather than a normal occurrence. To the modern student of science there is no great difference between the composition of our earth and that of extra-terrestrial masses. The mineral peridot is a constant extra-terrestrial visitor, present in most meteorites. And yet no one doubts that peridot is also a true constituent of rocks formed on this earth. The spectroscope reveals that the elementary composition of the stars and the earth are pretty much the same; and the spectroscope also shows that meteorites have as much of earth as of heaven in their composition. Indeed, not only are the selfsame elements present in meteorites, but they are combined in the same way to form the same minerals as in the crust of the earth.

It is certain from observations I have made, corroborated by experience gained in the laboratory, that iron at a high temperature and under great pressure—conditions existent at great depths below the surface of the earth—acts as the long-sought solvent for carbon, and will allow it to crystallize out in the form of diamond. But it is also certain, from the evidence afforded by the Arizona and other meteorites, that similar conditions have existed among bodies in space, and that on more than one occasion a meteorite freighted with jewels has fallen as a star from the sky.

Many circumstances point to the conclusion that the diamond of the chemist and the diamond of the mine are strangely akin as to origin. It is evident that the diamond has not been formed *in situ* in the blue ground. The genesis must have taken place at vast depths under enormous pressure. The explosion of large diamonds on coming to the surface shows extreme tension. More diamonds are found in fragments and splinters than in perfect crystals; and it is noteworthy that although these splinters and fragments must be derived from the breaking up of a large crystal, yet in only one instance have pieces been

* Abstract of a lecture delivered before the South African meeting of the British Association for the Advancement of Science.

* Sir James Dewar, in a Friday evening discourse at the Royal Institution, 1880, showed an experiment proving that the temperature of the interior of a carbon tube heated by an outside electric arc was higher than that of the oxy-hydrogen flame. He placed a few small crystals of diamond in the carbon tube, and, maintaining a current of hydrogen to prevent oxidation, raised the temperature of the tube in an electric furnace to that of the arc. In a few minutes the diamond was transformed into graphite. At first sight this would seem to show that diamond cannot be formed at temperatures above that of the arc. It is probable, however, for reasons given above, that at exceedingly high pressures the result would be different.

† The silica was in the form of spheres, perfectly shaped and transparent, mostly colorless, but among them several of a ruby color. When 5 per cent of silica was added to cordite, the residue of the closed vessel explosion contained a much larger quantity of these spheres.

‡ "The Diamond Mines of South Africa," p. 510; Macmillans, 1902.

§ Chemical News, vol. lxi., p. 309, 1890.

found which could be fitted together, and these occurred at different levels. Does not this fact point to the conclusion that the blue ground is not their true matrix? Nature does not make fragments of crystals. As the edges of the crystals are still sharp and unabraded, the *locus* of formation cannot have been very distant from the present sites. There were probably many sites of crystallization differing in place and time, or we should not see such distinctive characters in the gems from different mines, nor indeed in the diamonds from different parts of the same mine.

It is not difficult to imagine that masses of iron saturated with carbon existed formerly at a sufficient depth below the present mines, where temperature and pressure would produce the reactions which laboratory experiments show to be probable.

(To be continued.)

ELECTRICAL NOTES.

All the oxides which had hitherto been regarded as irreducible have been reduced through the use of the electric furnace. Upon experiments which he has made Borchers bases the claim that carbon is capable of taking the oxygen from any known compound at temperatures within the range of the electric furnace. Similarly, other reducing agents may be made effective, and the decomposition can be produced without any reducing agent whatever by utilizing the electrolytic action of the current. This has resulted in unlocking various of nature's stores, making available for man's use such materials as aluminium, magnesium, calcium, sodium, potassium, chromium, silicon, and many others which previously could be obtained only with great difficulty if at all.

Extreme accuracy is now so frequently claimed for the daily newspapers that the following note clipped by Engineering Record from a Wabash paper is worth reading: "The power house will be a place of miracles to the lay mind, which may then watch electricity sucked from the air at 370 volts and multiplied to 33,000 volts by processes which electricians know as phenomena, and not as science. The reason why is apparently beyond mortal ken, but the results satisfy the commercial purposes, and the tendency of the great mass is 'to let it go at that.' The transformer that by the power that is called 'induction,' for lack of a better name, will step up the number of volts, will be inclosed in oil, and the apartment walled in will have doors so that if it gets out of repair it can be easily and safely handled. It will be dangerous to approach it within six feet, and it will be controlled at a safe distance by those in charge." This recalls the definition of a lightning arrester as a "device for utilizing the residual energy of the clouds," which appeared in a California paper.

It is a well-known fact that considerable danger is incurred in approaching too close to working Röntgen bulbs, when besides serious lesions of the skin, an atrophying action is observed on certain glands. In a memoir recently presented to the French Academy of Sciences, Mr. J. Bergonié suggests a rather effective method of protection against these undesirable effects, this method having been used to advantage for six months at the hospitals of Bordeaux University. In principle it consists in placing the whole of the surroundings of the patient above the horizontal plane, continuing the anti-cathode, and only the patient below this plane. The space is thus separated into two parts, one of which, viz., the upper part, is so entirely protected against any action of X-rays, that sensitive radiographic plates can be handled there close to the bulb without risking the production of any veil on them. It may be mentioned that such methods as have so far been suggested have been found insufficient, the electrical field in the neighborhood of the bulb being altered by the arrangement of diaphragms, while the most serious drawback of protective screens is their interfering with the freedom of manipulation of the operator.

A process of forming yellow arsenic by the action of the electric arc has been recently described by A. Stock and W. Sieber. In 1902 two German scientists, Erdmann and Unruh, succeeded in preparing a sulphocarbonate solution of yellow arsenic. The process is based upon the vaporization of ordinary arsenic in an aluminium tube and the vapor is drawn off by a rapid current of carbonic acid gas into a recipient containing sulphide of carbon which is kept cold. The authors now propose to modify this process so as to obtain the solution in large quantities. To carry this out they use an electric arc which is formed between two electrodes of arsenic in the midst of a carbon disulphide solution. As the arsenic is vaporized in the arc it is dissolved in the liquid, for the most part in the form of the yellow modification. The experiment is easily made by forming the arc in an inner glass vessel placed in the middle of a two-gallon jar. The electrodes are placed in the lower part of the inner vessel and covered to a certain height with bisulphide of carbon. Both vessels are then filled up with ice-water. They use a current of 110 volts with a resistance of 10 ohms in the circuit of the arc. The anode may be formed of carbon, as the effect takes place at the cathode. The latter is formed of an alloy of equal parts of arsenic and antimony. When the arc is formed, the antimony falls down in the form of a fine black powder and does not enter in solution like the arsenic. Care should be taken not to concentrate the solution beyond a certain point, otherwise the arsenic is precipitated rapidly and is transformed to the black insoluble form.

SCIENCE NOTES.

A hundred years ago light was thought to be a kind of corpuscle, and now we call it a wave motion in the ether, and say there is no such *thing* as light, it is merely a condition of the ether in the same sense as heat is a condition of matter; and there are some physicists who go farther and declare it to be only an optical illusion, a physiological phenomenon that does not exist apart from the mechanism of the eye. Such have proposed we discard the word light from physical science, seeing it is only a condition of the optical apparatus. At any rate, the nature of light is now so well known and understood that no one thinks of asking the question "What is light?" but the answer we give is a long remove from the answer expected a hundred years ago.

The science of statistics, which has done great service in public health science in the past, is likely to do much more in the future. Without accurate statistics of population, mortality and the causes of sickness and death, the science of epidemiology is impotent, and the efficiency or inefficiency of public health measures can not be determined. And yet in ignorant hands statistics may be worse than useless. It is a matter for congratulation to Americans that we now have in Washington a census bureau permanently established and under expert supervision, but until the various States and cities of the United States follow this excellent example of their federal government, one of the most important aids to public health science will continue to be wanting, as is unfortunately too often the case to-day not only in America, but in many other parts of the civilized world.

If one may judge from a recent bulletin by Mr. E. Dwight Sanderson, issued by the United States Department of Agriculture, the cotton plant has not only the boll weevil to contend with in its struggle for existence, but a whole army of insect parasites. As soon as a young plant begins to grow, many are destroyed by cut-worms, which nibble off the stems and often render it necessary to replant a considerable area. With the formation of the first true leaves of the cotton, winged plant lice appear in large numbers on the under side of the leaves and on the terminals. Often indeed the buds of the plants are black with them. If it escapes the ravages of the plant lice, the new cotton may fall a prey to the web worm. The larvæ of the white-lined sphinx moth are likewise common pests of cotton fields. Occasionally their numbers are such that they destroy all low-growing vegetation in their path. The differential locust, by far the most injurious grasshopper in Texas, often cripples a cotton field; and in the spring of 1904 young differential locusts just after they had hatched from the eggs destroyed the young cotton to an alarming extent. Two species of wingless May beetles may seriously injure young cotton. The salt marsh caterpillar, which is one of the "woolly bear" caterpillars, and is covered with long black and red hair, is a particularly virulent enemy. It is said that when fully grown it even resists attempts to poison it with Paris green. Still other insects which cotton planters fear are the large tiger moth, the army worm, the fall army worm, the Io moth, the cotton belt cutworm, the leaf-cutting ant, the cotton-stalk borer, the tree cricket, the cotton square borer, cotton sharpshooters, leaf-footed plant bugs, click beetles, cowled weevils, acorn weevils, and plaster weevils.

The Hessian fly is distinctly a wheat pest, although doing some damage also to rye and barley. The losses due to this insect will be considered more in detail to indicate their nature specifically and to illustrate the exactness and reliability which may sometimes characterize records of this kind relating to particular pests of a single crop. The season of 1900 is notable in Hessian-fly annals as exhibiting the most destructive work of this pest in recent years. The fly was very generally present throughout the main wheat-growing districts of the Ohio and Mississippi valleys, but its ravages were this year concentrated particularly in Ohio and Indiana. The statistics of the acreage and yield of wheat and value of the crop for this year for the States mentioned reflect very plainly the loss occasioned by this pest. The wheat area in these two States in 1900 and the years immediately preceding was about 5,000,000 acres. Chiefly on account of the ravages of the Hessian fly more than half of this acreage (2,577,000 acres) had been abandoned and planted to other crops prior to May 1, 1900, as shown by the records collected by the Bureau of Statistics of this Department. The abandonment was about 40 per cent for Ohio and 60 per cent for Indiana. The cost of the preparation of soil, planting, and seed wheat for this abandoned acreage is all that need be reckoned, inasmuch as it was possible to use the land for other crops, such as corn or oats. The loss in labor and material indicated will approximate $3.50 per acre, giving a total of over $9,000,000. Of the remaining wheat acreage, the average yield per acre for this year in Ohio was 6 bushels as against 15.3 bushels for the year following, 14.2 bushels for the year previous, and nearly 17 bushels for the years 1897 and 1898. For Indiana, the yield per acre in 1900 was only 5.3 bushels as contrasted with 15.8 bushels for 1901, and 15.6 and 9.8 bushels, respectively, for 1898 and 1899. In other words, a decrease in the yield per acre is shown of nearly two-thirds, for these two States, for the area in wheat which was left for harvesting. The Hessian fly does more or less damage every year, which reduces the average yield per acre, and, therefore, if such damage be eliminated, the average yield per acre should be in the neighborhood of 15 bushels, indicating a loss for this year from the Hessian fly of nearly 10 bushels per acre for the area harvested, or, for the two States, of 24,230,000 bushels of wheat, of approximately a farm value (at the low price for that year) of $15,000,000. This loss, combined with the $9,000,000 indicated for the abandoned acreage, gives a total direct loss for these two States of over $24,000,000. These figures, enormous as they are, are based on the careful statistical records of the acreage, yield, and prices of 1900 collected by the Statistician of the Department, working entirely independently of the Bureau of Entomology.

ENGINEERING NOTES.

A source of considerable loss in the operation of steam plants, particularly large ones, is the insufficient size of piping, causing the pressure to be reduced between the boiler and engine, and imperfect drainage, which is an enemy both to economy and the life of the engine. In many of the newer plants, it has been found a great advantage to install large receivers to equalize the pressure and to collect the water before it reaches the engine.

A locomotive steam boiler well designed and constructed of the best material, when of the capacity to perform the work required of it, and properly cared for, should last in good condition from twenty to thirty years, and in general practice the condition of the water used is of very marked importance, for upon the impurities held in suspension, or solution, depends not only the economy of operation and maintenance, but the life of the boiler itself. Almost all natural water contains more or less mineral matter held in solution, as well as the organic and mineral matter held in suspension. While the latter may be removed by filtration, the former can be removed only by the agency of heat or chemicals.

About 1886, a new type of iron structure came into existence, viz., the iron skeleton construction for buildings, which has opened a new field for the structural engineer. The designing and construction of the structural part of these buildings has now become an important branch of engineering. Any engineer who has followed the progress of American bridge building for the last thirty-five years must have observed that, not only the designs, but also the methods adopted for accomplishing results, have undergone a vast transformation; while, abroad, the designs have been improved, but the methods have changed very little, if at all. The practice of having the designs of bridges and other structures made by engineers employed by the purchaser, and letting the contract to a manufacturer on a pound price basis, is now becoming the standard practice of the country. Most of the large railroads have their own bridge and structural departments, or, for work of unusual magnitude, employ outside experts to design and supervise construction. Only a few of the smallest railroads adhere to the ancient practice of inviting manufacturers to submit competitive designs accompanied by a lump-sum bid.

The equipment of a castor-oil mill is identical in its main feature with that of a linseed-oil mill or of a cottonseed-oil mill, that is, the mechanical unit of production is the hydraulic press. Oil is obtained from castor beans, as it now is most commonly from all oleaginous seeds, by hydraulic pressure. In the preparation of the beans for pressure and in the clarifying and refining of the oil after expression it is possible that slightly different processes are used in different mills; consequently, as is natural in a small industry like this, considerable reserve is maintained by owners concerning even the mechanical operations of their plants. The principal features of the process of extracting oil from castor beans, however, are evident. The beans, first cleansed of fragments of capsules, stones, dust, etc., an operation that in the case of imported beans entails a loss of from two to five per cent, are not decorticated, as cotton seed is, nor crushed between rolls as most oleaginous seeds are, but are pressed whole. Decortication is not necessary, and the operation of crushing is impracticable, because the beans would cake too much upon the rolls. They are heated or not before pressure, according to the purposes for which the oil is destined. Heat renders the oil in the beans sufficiently liquid for easy expression, but, if carried to a degree higher than the hand can easily bear, has a tendency to discolor the oil and render it unfit for medicinal and undesirable for some other uses. The more common custom, therefore, is to press the beans cold by submitting them, inclosed in bags, to gradual pressure for the requisite length of time in a powerful hydraulic press. In most mills the practice seems to be to submit the beans to a single pressing. This custom differs from that prevailing in some other countries, where after the first pressing the pulp or pomace is removed from the press, broken into pieces, heated, and submitted to pressure a second or even a third time, each subsequent pressing, however, producing a lower grade of oil. The oil as it flows from the press is a whitish liquid, from which the starch, albumen, and mucilage are afterward removed by careful processes of clarifying and refining; the resultant product is the castor oil of commerce. Two grades are placed upon the market, known commercially as No. 1 and No. 3. The former grade commands the higher price and enters largely into medicinal uses; the latter is usually quoted at from one-half to 1 cent less per pound, and supplies various industrial needs. Both grades are sold by the pound, or unit of weight, and have lately been commanding from 9 to 11 cents per pound as compared with 10 to 12 cents per pound a few years ago.

TRADE NOTES AND RECIPES.

Protection of Wood Against Moisture.—Often the wooden portions of machines are so damaged by dampness prevailing in the shops that the following compound will be found useful for their protection: Melt 375 grammes of colophony in an iron vessel, and add 10 liters of tar and 500 grammes of sulphur. Color with brown ocher or any other coloring matter diluted with linseed oil. Make a first light application of this mixture while warm, and after drying apply a second coat.—Revue des Produits Chimiques.

How to Polish Cast-Tin Covers.—Articles of tin should be ground and polished with Vienna lime or Spanish white. The former may be spread on linen rags, the latter on wash leather. Good results may be obtained by a mixture of about equal parts of Vienna lime, chalk, and tripoli. It should be moistened with alcohol, and applied with a brush. Subsequent rubbing with roeskin (chamois) will produce a first-rate polish. Tin being a soft metal, the above polishing substances may be very fine.—Der Metallarbeiter.

To Soften Iron Castings.—To soften hard iron castings, the Deutsche Schlosserzeitung recommends the following process: Heat the object to a high temperature, cover it over with fine coal-dust or some similar substance, and allow it to cool gradually. When the articles are of small size, a number of them are packed in a crucible with substances yielding carbon to iron at a glowing heat. The crucible is then tightly closed, and placed in a stove or on an open fire. It is gradually heated and kept at a glow heat for several hours, and then allowed to cool slowly. Cast-iron turnings, carbonate of soda, and unrefined sugar are recommended as substances suitable for packing in the crucible with the castings. If unrefined sugar alone is added, the quantity must not be too small. By this process the iron may be rendered so soft that it may almost be cut with a knife.

Platinizing Vessels of Aluminium.—Aluminium vessels coated with a layer of platinum are recommended by A. Gavalowski in the Zeitschrift für Analytische Chemie in place of platinum vessels which are not exposed to very high temperatures. The process of platinizing, according to him, is very simple, consisting in rubbing the aluminium surface, previously polished, with platinic chloride, rendered slightly alkaline. The layer of platinum is made thicker by repeated application. Potash lye is carefully added to a solution of 5 to 10 per cent of platinic chloride in water till a slightly alkaline reaction is produced on filtering paper or a porcelain plate by means of phenolphthalein. This solution must always be freshly prepared, and is the best for the purpose. Neither galvanizing nor amalgamating will produce the desired result. Special care must be taken that the aluminium is free from iron, otherwise black patches will arise which cannot afterward be removed. Vessels platinized in this way must not be cleaned with substances such as sea-sand, but with a 5 to 10 per cent solution of oxalic acid in water, followed by thorough rinsing in water. These vessels are said to be specially suitable for evaporating purposes.

To Make Silver Amalgam.—Silver amalgam can easily be made with the help of finely-powdered silver. The mercury need only be heated to 250 deg. to 300 deg. C.; silver powder is then sprinkled on it, and mixed with it by stirring. The vessel is heated for several minutes and then allowed to get cool, the excess of mercury being removed from the granulated crystalline amalgam by pressing in a leather bag. Silver amalgam can also easily be made by dissolving silver in nitric acid, evaporating the solution till the excess of free acid is eliminated, diluting with distilled water, and adding mercury to the fluid in the proportion of four parts by weight of mercury to one of the silver originally used. The mercury precipitates the silver in a metallic state, and immediately forms an amalgam with it; the fluid standing above after a time contains no more silver, but consists of a solution of mercurous nitrate mixed with whatever copper was contained in the dissolved silver in the form of copper nitrate. The absence of a white caseous precipitate, if a few drops of hydrochloric acid are added to a sample of the fluid in a test tube, shows that all the silver has been eliminated from the solution and is present in the form of amalgam.—Die Edelmetall-Industrie.

How to Make Superficially Tinned Lead-plate.—When it is required to make tinned lead-plates, this is best done by plating. For this purpose a table with a perfectly even iron surface and provided with vertical raised edges to prevent the melted metal from flowing away, is employed. The lead is poured on this table, and covered with grease to prevent oxidation of the surface. As soon as the lead is congealed, melted tin is poured over it, care being taken that the tin is sufficiently heated to remelt the surface of the lead and combine thoroughly with it. When the plate is sufficiently cooled, it is turned over, and the lower surface treated in the same way. The plate, thus tinned on both sides, is then placed between rollers, and can be rolled into very thin sheets without injury to the tin coating. These sheets, doubly coated with tin by this process, are specially adapted for lining cases intended for the transport of biscuits, chocolate, candies, tea, snuff, etc. If lead-plates are only to be tinned superficially, they are heated to a tolerably high temperature, and sprinkled with powdered resin; melted tin is then rubbed on the surface of the plate with a ball of tow. It is advisable to give the lead a fairly thick coating of tin, as the latter is rendered thinner by the subsequent rolling.—Der Metallarbeiter.

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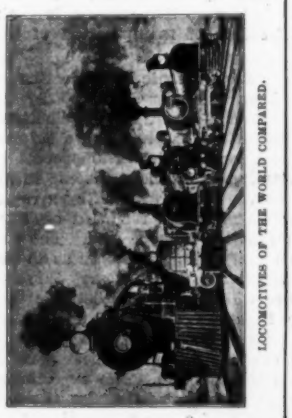

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